REPORT

OF THE

Commissioner of Agriculture.

1887.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1888.

[PUBLIC RESOLUTION—No. 20.]

Joint resolution authorizing the printing of the Annual Report of the Commissioner of Agriculture for the year eighteen hundred and eighty-seven.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That there be printed four hundred thousand copies of the Annual Report of the Commissioner of Agriculture for the year eighteen hundred and eighty-seven; seventy thousand copies for the use of members of the Senate, three hundred thousand copies for the use of members of the House of Representatives, and thirty thousand copies for the use of the Department of Agriculture; the illustrations for the same to be executed under the supervision of the Public Printer, in accordance with directions of the Joint Committee on Printing, said illustrations to be subject to the approval of the Commissioner of Agriculture.

SEC. 2. That the sum of two hundred thousand dollars, or so much thereof as may be necessary, is hereby appropriated, out of any money in the Treasury not otherwise appropriated, to defray the cost of the printing of said Report.

Approved, March 3, 1887.

TABLE OF CONTENTS.

LIST OF ILLUSTRATIONS.

REPORT

OF THE

COMMISSIONER OF AGRICULTURE.

DEPARTMENT OF AGRICULTURE,
COMMISSIONER'S OFFICE,
Washington, D. C., November 15, 1887.

To the PRESIDENT:

I respectfully submit my third annual report as Commissioner of Agriculture.

The year has been crowned with plenty, though in a large and fertile district, in the heart of the summer, the heavens were brass and the earth ashes. Even fervid suns and cloudless skies have failed to convert the fat areas of alluvium into a desert. When a field of maize, with only a sprinkling of water from planting, is able to mature 40 bushels to the acre, nothing but careless cultivation can destroy the crop. It is a truth, which observation affirms and reiterates, that natural disabilities, however heavy, are less injurious than bad cultivation, and can be measurably obviated by the intelligence, alertness, and skill of the good farmer. It is the crop of the poor cultivator that is burned with drought, eaten by insects, or caught by the frost; if the skilled husbandman suffers a partial loss, his large remainder sold at appreciated prices nets a fair return.

The last seven years have been, with one exception, seasons of less than medium yields of corn, the great American tillage crop, and yet there has been no famine; exportation to Europe has been only limited by enhancement of price; and the home consumption of this one crop has averaged nearly twice as many bushels per capita as the European consumption of all the cereals in the same time. The great American desert of thirty years ago continues, as for several consecutive seasons, to pour its wealth of production into the nation's granary of maize, and stands in rate of yield among the most favored districts of the land.

The food question which most agitates the farmers of other countries is American competition in the wheat markets of the world. In the western nations of Europe such competition has been serious,

reducing rents, consuming the tenants' surplus, and deepening the agricultural gloom and depression. Still it continues. One-third of the wheat crop of last year was exported. More than half of the wheat and flour imports into Great Britain are still from this country, and last year the proportion from America was increased, while that from India was diminished. Whether profitable or not, the exportation still continues, and is likely to continue while virgin areas of wheat lands are annually broken as emigration extends westward. The comparative prominence of this country in its wheat surplus may not be popularly realized. Where our exports have exceeded 136,000,000 bushels per annum for ten years, those of Russia were about 66,000,000 bushels and those of India 24,000,000 bushels, in round numbers, for the last decade. Other lands contribute only a very small surplus—Australia, Chili, the Argentine Republic, and others only a few millions each—and the combined surplus of all nations does not equal that of this country.

It is an important question, in view of the rapid increase of available rural labor, tending to overproduction of the fruits of the soil and the cheapening of their values, what can be done to give greater variety to the products of agriculture? What can this Department do towards the introduction of new plants and the development of new rural industries? The sugar problem is one of the largest, but there may be a thousand minor products of cultivation, fruits, fibers, medicinal plants, dyes, and many others, which together may make an aggregate surpassing that of the largest single product.

In the established industry of meat production, which is as old as agriculture, there is ample opportunity for economy and for success snatched from narrower margins of profit. The wastes of the past have been enormous. Neglect of improvement in blood, irregular feeding, exposure with semi-starvation, and waste of rough material in the fields, have increased the cost of meat and reduced its quality and intrinsic value. The successful feeder realizes the necessity of continuous and liberal feeding, and understands well the loss in flesh and its reduction in quality in alternate stuffing and starving. There are multitudes, however, who do not understand or who fail to heed it. As the cost of corn and other material increases, the margin for profit is liable to be narrowed, rendering necessary the practice of all possible economies and the use of all available material in meat-making. It should be understood, however, that meat here, as elsewhere, now, as ever, promises to pay the farmer better than grain. The tendency has been to comparative advantage in price. The grass lands in times of agricultural depression yield the better profit. Their proportion is increasing to-day in Great Britain, where agricultural lands are dearest, from this cause.

There is a branch of meat-making that has been neglected in this country. Sheep husbandry has been followed for the production of

wool rather than for mutton. The latter production has been so neglected as to render scarce meat of superior quality, tending to prevent the desirable increase of mutton consumption. In many sections it is unpopular because the popular taste has had no opportunity to appreciate fine quality. There is a wide field for improvement in quality and cost of this healthful and nutritious flesh, and the additional product of the fleece should render mutton sheep profitable, however wool may fluctuate in value.

To the solution of these and many other problems of husbandry the effort of the Department is persistently and zealously directed.

The Department of Agriculture to-day presents a striking and instructive contrast with its status when established as a separate Department in 1862. The organic law but faintly outlines the present labors and purposes of the Department. At its organization there were but three divisions in the Department and but few employés; indeed, but one, the seed division, was generally known to exist, and to many minds its one object, the gratuitous distribution of garden and field seeds to miscellaneous applicants, comprised the beginning and the end of its aims and efforts.

But the Department has been able, under many and trying situations and despite the prejudices which were born of these misconceptions and the banter of cavilers, to keep pace with the development of the rural economies of our people, and it has so well commended itself to the country and to Congress that it has to-day no less than twenty separate and distinct branches, each busy in its own specialty and duty, and many of them sending through the country thousands of circulars, bulletins, and reports showing what science has to teach of the problems of the soil, of the insects which depredate, of the diseases which devastate, of the various other questions which continually confront our agriculturists, and making, as a whole, an aggregation of scientific effort suggesting advancement and improvement in agricultural endeavor.

The position which the Department occupies to-day, then, is that of an adviser in those investigations and enterprises which are to have an important bearing upon the future agriculture of this country. In the beginning the Department may have been an experiment, but its condition now should leave no doubt as to the precise relation which the Department should hold to the Government. The development has been natural, and there may be a valuable lesson in the history of its evolution. The relation to which I refer needs to be recognized, not through the mere changing of a name, not through any radical legislation which may meet the favor of one class and the disfavor of another, nor yet through any entangling alliances which would only serve to distract attention from the one great and leading thought which should always possess those who administer the affairs of the Department, but rather through a well-

endowed department, fully authorized to employ scientific experts and specialists in its several lines of investigation at just and reasonable compensation, fully equipped with the latest and most approved apparatus, with conveniently arranged work-shops and safe and healthful surroundings. If it is wise to prepare for war in time of peace, shall we not give a thought at least to famine in time of plenty? Our farming population is not always to enjoy the blessings of the returns from a virgin soil. Science and sense are to be the handmaidens of our future agriculture and commerce, and it is not too soon for us to anticipate what the requirements are to be if we are to continue in our present state of agricultural independence and supremacy.

The salaries paid in this Department for scientific and special work are not in proportion to those paid in other branches of Government and in private institutions for work of a like responsibility. During the year other Departments of the Government, as well as a State agricultural institution, have been enabled to take from the chemical division of this Department three of its best chemists and transfer them at largely increased salaries. A chemist, or any other employé, ought to be worth as much in this Department as in any other; but the equalization will only come when the Department has a well-defined, distinct status, where its needs and requirements will have that recognition and respect which are accorded to the older Departments.

It has been my aim during the year to continue established lines of investigation, and to inaugurate new ones for which a necessity appeared to exist in the progress of development of the Department and of national agriculture. Five new sections have been organized during the present administration.

The Department was established to subserve the various interests and industries of agriculture. Plants and seeds that are the germs of future rural industries have been introduced; experiments that are to cheapen and facilitate production, and those that may have an exceedingly important bearing upon our industrial economy and national wealth, have been made; organized effort has been essayed to secure early and accurate information of the crop products, to give the isolated producer all the information which the buyer can possibly obtain; and various practical applications of the latest discoveries of science, that are needed to relieve the burden of toil, have either been initiated already or form a part of a vast array of investigation which only awaits the necessary encouragement on the part of the legislative branch of the Government.

Nothing better illustrates the present status of the Department than the gratifying demand for its various official reports. No less than 380,800 copies of these have been published and distributed the past year—a record which exceeds anything within the history of the

Department by nearly 150,000 copies. But this does not include all the information disseminated by the Department. Congress distributed, through its Members and Senators, 375,000 copies of the Department's Annual Report of last year, and, in addition, also distributed directly several thousand volumes of special reports prepared by the Department.

Nor does this indicate fully the wide-spread interest in the work in which the Department is engaged. Invitations are constantly being received by the Department to send its representatives in some particular branch of science to conventions and meetings that are called to discuss the problems of agriculture. I have considered it my highest duty to respond to this demand as far as possible, and I have sent agents to various parts of the country to meet with and confer with the people for the purpose of discussing those questions which relate to the common weal. The Department has exchanged in this way the experiences of science for those of practice, and its agents have been enabled to acquaint themselves with the immediate wants of those assembled and to supply the information required to institute the needed investigations. It will be realized, therefore, that the Department of Agriculture, through its publications and through these efforts, may benefit incalculably a vast constituency, and that a successful administration of its affairs can only be conducted through a vigilant, energetic, and progressive policy.

During the year I have constantly endeavored to administer the office in this spirit. There have been experiments conducted which promise interesting results, and one of which bids fair to signalize the year of 1887 as one of the most important in our history. The manufacture of sugar from sorghum is a question to which time and money have been devoted by Government and by private enterprise. Varied successes have been achieved. Success has alternated with failure, from a financial point of view; encouragement has given way to discouragement, and enthusiasm to lethargy, until recently, when the Department conceived the idea of applying an entirely new process, so far as sorghum was concerned, but one known throughout Europe as applied to the extraction of sugar from the beet.

Enough was shown in experimental work with the diffusion process to justify me in sending an agent abroad to study the details of the machinery, to personally examine the several methods of manipulation, etc., and to acquaint himself generally with those points, in detail, which might be conducive of success. In this, as in many other instances that might be cited, the information and experience thus secured proved to be only the germ of what was to be the new process, American genius and American thought quickly applying themselves and solving the mechanical and other difficulties which were as sure

to be met with in adjusting beet machinery to the uses of the sorghum plant and in the manipulation of its juices as in any other radical change. However many mistakes were made, however much sacrifice of time and money and thought were involved, whoever may be entitled to criticisms for temporary failures or plaudits for successful experiments, one thing seems sufficiently assured to outweigh all other considerations as to how the victory was accomplished, *i. e.*, the solution at last of the problems which are involved in the economical and successful manufacture of sugar from sorghum. It is yet too early to make to you an official report of the results, in detail, of the present year's experiments in this direction, but enough is known already, I think, to enable this country to anticipate, at an early day, the production of a sugar supply from a plant as easy of cultivation as corn, but little circumscribed by climatic influences, and one whose by-products have a value equal to the cost of raising.

In my first annual report I referred to the gratifying results of a convention, composed of delegates from agricultural colleges and experiment stations, called by me for the purpose of developing a system for the unification of the results of experiments and reports by them. The succeeding year I devoted a goodly space in my report to you to a survey of the field of experimental agriculture. I am happy to say that Congress, at its last session, enacted a law providing for governmental aid in this direction, through the respective experiment stations of the country, and another meeting of the delegates referred to was held at this Department in October last, to discuss the adaptation of the measure to the respective stations and to agree upon a uniform plan of operation. The meeting was an eminently successful one; it was fully reported for the Department, and its proceedings will be published as a special report. The result of the meeting was moreover a most gratifying outcome of my efforts to establish relations which ought long ago to have existed between this Department and the several colleges and stations. Happily the bill in question will result in much good, and much more can be accomplished if Congress will recognize the necessity, which has become quite imperative at this stage in the progress of scientific experiment in aid of practical agriculture, of the establishment, under the immediate supervision of this Department, of a central experiment station, with proper accessories, for the investigation of questions affecting large areas, and such as relate to the whole country. This should constitute, in connection with a properly organized clerical force, a division of the Department, charged with the duty of collating and consolidating the main results of work of all experiment stations, of co-ordinating their work, and disseminating the results obtained, and of presenting also the results of similar research in other countries. I recommend the establishment of such a station and division in this Department.

BUREAU OF ANIMAL INDUSTRY.

The work of this Bureau has been greatly increased and extended during the past year. The appropriation act approved June 30, 1886, gave authority to expend money for the purchase and destruction of diseased animals whenever it is essential to prevent the spread of pleuro-pneumonia from one State into another. The total eradication of the plague being necessary, in the opinion of experts, to prevent its spread from State to State, it was decided to use the money appropriated in the purchase and destruction of diseased cattle wherever this action would have a tendency to secure such eradication. It was evident, however, that to purchase diseased animals wherever found would not effect such eradication unless, by co-operation with State authorities, regulations could be enforced which would secure the control of exposed animals and the disinfection of premises.

In August, 1886, by co-operation with the authorities of the State of Maryland, the purchase and destruction of cattle affected with pleuro-pneumonia was begun. In this case the exposed cattle were to be disposed of by the Maryland Live Stock Sanitary Commission under the State laws. Owing to the expense attending the quarantining and slaughter of exposed cattle, few other States were willing to co-operate for the extirpation of this malady until after the appropriation act approved March 3, 1887, went into effect. This act increased the appropriation to $500,000, and authorized the use of "any part of this sum in the purchase and destruction of diseased or exposed animals and the quarantine of the same."

Immediately after this bill became a law, rules and regulations were prepared in accordance with section 3 of the act of May 29, 1884, and were certified to the governors of all the States and Territories, with a request for their co-operation in enforcing them. The governors of thirty-one States and Territories have accepted these rules and regulations, and have promised the assistance of local police officers to secure their enforcement. In addition to this the legislatures of the States of Rhode Island, Virginia, New York, and Illinois have enacted laws providing for co-operation and placing the work in charge of the Bureau of Animal Industry. With these laws and regulations the work of the Bureau has been carried on in all of the States where pleuro-pneumonia has been known to exist, with the single exception of Pennsylvania. The governor of Pennsylvania has expressed his desire to co-operate, so far as is possible under the laws of his State; but as the officers in charge of this work found but few infected herds, and reported that these were promptly disposed of according to State law, the necessity of action by this Department is not yet apparent.

The worst infected counties, and those from which there was most danger of the spread of the disease, viz, Cook County, in Illinois;

Westchester, New York, Richmond, Kings, Queens, and Suffolk, in New York; and Baltimore, Howard, Carroll, and Prince George's, in Maryland, have been placed in quarantine and no cattle allowed to leave them without a permit issued after a special examination. By this means new outbreaks have been almost entirely prevented. Before these regulations were made the contagion was carried to the counties of Washington and Delaware, in the State of New York, and quite widely disseminated. It was stamped out, however, without any serious interference with the trade and commerce of these sections. It was also carried into several counties of New Jersey, but in the most of these cases it has been extirpated.

From the beginning of the work for the eradication of this disease, in August, 1886, to October 31, 1887, the inspectors of this Bureau have carefully inspected 15,387 herds, containing 117,480 animals, in districts where the plague was supposed to exist. Among these there were found 798 infected herds, containing 10,766 animals, of which 2,235 were affected with pleuro-pneumonia. These figures do not include 2,873 head of cattle in the distillery stables of Chicago, nearly half of which were diseased. The number of animals found affected with this disease, and the number of infected herds, were much greater than had been anticipated, and the work for its control has consequently required a correspondingly larger force and greater expenditure of money. Our progress, however, has been very satisfactory, and the appropriation has been found sufficient to meet the demands which have been made upon it.

At the time of writing my last report the serious outbreak of pleuro-pneumonia at Chicago, Ill., had recently been discovered, and there was great danger that the plague would extend and cripple the great cattle industry of the Western States. By promptly placing a guard over the worst infected stables, and by co-operation with the State authorities for the destruction of all diseased and exposed cattle and the thorough disinfection of premises, the contagion was not only prevented from spreading, but I am happy to say it has been entirely extirpated. The restrictions placed upon the movement of cattle from Illinois by the authorities of other States and Territories are now being removed, and within a short time this interstate traffic will again be carried on with entire freedom. While the loss to the farmers of Illinois from this temporary interruption of trade has been very heavy and the restrictions have been burdensome, it is a matter for congratulation that it was possible to remove the source of this trouble in so short a time.

The work done in Illinois from October 1, 1886, to November 1, 1887, is shown by the following figures: The total number of herds examined was 7,285, in which were found 24,161 head of cattle. *Post-mortem* examinations were made on the carcasses of 7,693 animals, of which 1,425 were found affected with pleuro-pneumonia. The total

number of cattle purchased for slaughter by the Department, because exposed or supposed to have been exposed to the contagion, was 988, of which 172 were affected with pleuro-pneumonia. The number of stables disinfected was 634. The total expense in suppressing this outbreak to October 31 has been $66,329.11, of which $3,179.53 was for affected and $13,560.03 for exposed animals. There will be some slight additions to these figures, as the accounts are not all adjusted and there is still some work to do.

Very satisfactory progress has been made in the other infected States. In New York there have been purchased for slaughter 646 exposed cattle and 153 affected ones; in New Jersey, 67 exposed and 57 affected; in Maryland, 1,287 exposed and 1,285 affected. The plague has been completely eradicated from Washington and Delaware Counties in the State of New York, and several counties in New Jersey and Maryland have been nearly or quite freed from it. A thorough inspection of the District of Columbia, and of the counties in Virginia which were infected at the time my previous report was written, shows that the disease no longer exists in these sections.

There has not been a time in years when this malady has been confined to such restricted areas as at present, and consequently the conditions are very favorable for its complete eradication. If the State authorities continue their co-operation as at present, which there is every reason to expect, and if an appropriation is made by Congress equal to that of the present fiscal year, and with authority for its similar use, it is believed that this dangerous plague can be exterminated by the end of the next fiscal year.

While the work for the suppression of pleuro-pneumonia has been by far the most extensive of any done by the Bureau, investigations of other contagious diseases have been made which have yielded very important results. Such investigations have for their object the discovery of the essential nature of these diseases and the methods by which they can be most effectually prevented. The advances of knowledge in this direction are not only of value to the farmer in assisting him to save his property, but they are of great advantage to the consumer by their tendency to improve the quality of the meat supply. To the country at large such questions are worthy of attention, since animal food can not be produced in abundance and cheaply in countries where animal plagues are allowed to ravage the flocks and herds without intelligent efforts for their control. Our country has been especially fortunate in the past in having but a limited number of such diseases to contend with, but with the increased importations from the Old World, and the shortening of the time required to make the voyage, other forms of contagion are being introduced, and unless proper regulations are made and enforced we will soon have to contend with all the maladies which have hindered the production of live stock in Europe and Asia. There must continue

to be, for this reason, an increasing demand for the services of the Bureau of Animal Industry, and the powers of the Bureau should be increased and its organization perfected, so that it may accomplish the entire work for which it was established.

In addition to the work for the investigation and control of animal diseases, inquiries have been made in connection with many special subjects bearing upon the economical production of animal products.

The quarantine of cattle from foreign countries has been maintained during the year by this Department. Owing to the low price of cattle in this country the importations have been very small. No case of contagious disease has been discovered among imported cattle since my last report, and the safety of our quarantine system is shown by the fact that no case of pleuro-pneumonia or other contagious disease has ever been traced to cattle which have been discharged from any one of our quarantine stations.

DIVISION OF ENTOMOLOGY.

The work of this division during the past year has been signalized by the completion of two important investigations; the one upon the Cottony Cushion-scale of California, and the other upon the Hop-louse. Both of these investigations were mentioned in my last report.

From the middle of March until nearly the middle of May the Entomologist was in California, concluding the first of these investigations and studying the other insect pests of that State. His observations supplemented those made by two field agents of the division, who were stationed in Los Angeles County during the greater part of the summer of 1886, and the results are included in the Annual Report for 1886. Other supplementary facts concerning this investigation, bearing for the most part upon the original habitat of the species and summarizing an extensive correspondence with naturalists in Australia, New Zealand, and South Australia, but also including the results of certain experiments with gases against this and other scale insects, have been published in Bulletin No. 15 of the division.

As stated in my last report, the Entomologist and one assistant visited the hop-fields in September, 1886, and made important observations. During the greater part of the present season three assistants have been stationed in the hop-growing region of New York State, one studying the life history of the Hop-louse, and the other two experimenting with different remedies, and particularly with cheap and effective means for the application of insecticides. Another agent was sent to the hop-fields of Wisconsin during August and a part of September, where he collected additional information and made confirmatory observations. The Entomologist, moreover, has

been in the field at several times in the course of the season superintending these observations, and the results of the investigation are more satisfactory even than I had hoped. There is now no reason why this pest, which last year damaged the crop to the extent of hundreds of thousands of dollars, should be longer feared by hop-growers.

In consequence of impaired health brought on by long overwork, the Entomologist was given four months' leave of absence without pay during the late summer and fall. In this time he visited Europe, and in England read papers before the Manchester meeting of the British Association, and carried on a series of observations upon the Hop-louse in that country, confirming observations made upon the same insect in this country, and announcing new and important facts in its life history to the English hop-growers. He also devoted some attention to the Hessian-fly question, which is at present profoundly agitating the agriculturists of Great Britain.

The Entomologist also visited the Continent and investigated the latest European insecticide machinery, a large mass of which he found to be simply reproductions or modifications of devices invented in the course of the investigations of his own division. The report of the international congress at Florence, mentioned in my last report, and which has just been published, indicates this fact very plainly, and it can but be a source of gratification in this country.

The investigation upon the Southern Buffalo-gnat has been continued during the present year. An agent has been stationed for the greater part of the season in Arkansas and Mississippi, and the results obtained have been of considerable practical value, although there are still several obscure points in the life history of the insect which, although they have so far baffled the skill of the observers of the division, will doubtless be cleared up another season, and may suggest a practical and easy means of fighting this great pest.

Considerable time has been devoted during the year to the collection of data concerning the Chinch-bug, which has been extremely injurious in several of the States, and also concerning the Plum Curculio and the Codling Moth. All of these are well-known insects and much has been written concerning them. There are, however, no standard articles which are readily available, and the Entomologist will include comprehensive accounts of each of these three insects in his annual report.

The publications of the division have been, in addition to the annual report of the Entomologist, Bulletins Nos. 10, 13, 14, 15, and 16.

Bulletin 10 comprises an account of the most injurious insect defoliators of our shade trees. It is illustrated with numerous text figures and by a plate, and was called forth by the damage

done by the Fall Web-worm and other insects to the shade trees of Washington and other Eastern cities during the last two years. Bulletin 13 contains reports from several agents of the division, including a report upon a sudden and disastrous outbreak of native locusts in Texas in1886; a report on insects injurious to forest and shade trees, continuing observations made during the past four years in New England and northern New York; a report on tests with insecticides upon garden insects in Ohio, and some general reports upon the insects of the year in certain of the States. Bulletin 14 contains a somewhat extensive report upon insects injurious to garden crops in Florida, resulting from observations and experiments made during the summer of 1886; a report upon the Buffalo-gnats and a report upon native plums and their influence upon the Curculio question. Bulletin 15 is devoted to matter concerning the Icerya or Fluted scale, known as the Cottony Cushion-scale of California, supplementary to that published in the Annual Report for 1886. Bulletin 16 contains a bibliography of the entomological writings of Dr. A. S. Packard, an agent of this division, and one of the most voluminous of living writers in entomology.

The increased funds at the disposal of the division have permitted the re-appointment of some of the field agents who were furloughed on account of the reduction of the appropriation for the fiscal year 1886–'87, and increased efficiency is the result, and the work of the division has never been more satisfactory than at present.

The correspondence of the division has increased even over its former large proportions, and it has become a serious question how to do it full justice without allowing it to seriously interfere with the special investigations being made. Over three thousand letters have been answered, and when it is remembered that each letter requires more or less research and consultation with the collections and with the literature of the subject, an idea of the time expended in this part of the divisional work can be gained.

The work of the apicultural experiment station has been carried on in the same lines laid down in my last report. For convenience in obtaining supplies, and for other reasons, the station has been removed from Aurora, Ill., to Hinsdale, Ill. The work has consisted of the study of the various kinds of diseases to which bees are subject, including an inquiry into the causes of disease and application of suitable remedies. The work in this line of investigation has been singularly successful and satisfactory. Suitable fixtures have been devised and constructed for securing the benefits resultant from selective breeding by means of skillful crossing of the different races of bees, and persistent effort has been made to secure the control of the process of reproduction. This feature of the work has been only partially successful, owing to the prevalence of a drought of unprecedented duration and severity, but much information of scientific

value has been obtained which will be of practical service under more favorable and normal climatic conditions.

Some progress has been made in testing the qualities and characteristics of some varieties of ancestral stock, and the results attained furnish encouraging assurances of what may be realized in the future in producing a variety of bees completely adapted to domestication under the varied conditions existing in different parts of the United States. Information concerning the wintering of bees, the values of different varieties of bee-forage plants, etc., have been obtained, and will have place in the reports of the agent in charge.

SILK.

There is no experiment, with the exception of those prosecuted in the manufacture of sugar from sorghum, to which I have given more thought during the year than to that now being conducted in the Department in the reeling of silk. Congress has been liberal in its assistance in this direction, and every energy has been put forth to solve the problem of the successful and profitable reeling of American cocoons.

The silk industry is one which well deserves most careful and intelligent thought. The raising of the cocoons depends upon no particular financial, commercial, or agricultural condition. It requires no capital, no factory, no skilled labor; the food upon which the worms feed matures soon after the winter's snow and spring rains, and is unaffected by the droughts of summer and unattended by diseases; and, above all, it is a work which may be carried on at the humblest cottage by the children, the women, and the aged of the family, and it offers a clean, pure, and interesting employment to those who would otherwise be unemployed at the rural home. The question then is, can it be made a profitable employment? Will there be the incentive of a market for American-grown cocoons? The experiments conducted during the year here, and those which I hope are to follow them, are to decide this important problem.

Already one question seems to have been decided which will be a source of national pride and patriotic congratulations, and will also abundantly repay the country for the outlay thus far made. For general operatives I have employed American girls. They were inexperienced and had never handled silk cocoons. A large portion of time has therefore been consumed in training this force in the requisite alertness and accuracy, but this has been deemed wise, because I had in view the promotion of a staff of American operatives thoroughly conversant with the trade, and therefore the sacrifice seemed justifiable. Of course, immediate return by way of profit could not be expected under such conditions, but I have the verbal admission of Mr. Serrell, the inventor of the reels with which I am now experimenting, after comparing the results obtained in one of

the processes of reeling, that the operatives in Washington can do twice as much work in a given time as the same number employed in the south of France.

This admission is fully corroborated by other evidence in my possession. An agent of the Department has examined into this matter this summer, and found in a large Italian establishment which he visited that there were employed a great number of very small girls, who received but about ten cents per diem. But it is generally conceded that the expense of watching and superintending these children more than counterbalanced the low price of their labor, even if the damage done through their lack of experience were not considered. He reports to me that, after full examination, it is his firm conviction that the superior intelligence of our American girls and their superior manner of living will overcome, in silk reeling, as readily as any of the other trades, the difference in the cost of labor between Europe and America.

At the same time it is too early yet to place entire reliance on this superior American intelligence; and these remarks would not accomplish their end if they were construed to mean that our superiority in this quality should outweigh the centuries of experience possessed by the French and Italians. To gain a like experience has been the chief aim of my assistants, with a view to making us ultimately independent of foreign experts.

One difficulty encountered has been the inferior quality of the cocoons purchased, many of which, though originally of excellent quality, have been ruined by improper stifling, or allowed to mold through negligence. That this difficulty is abating is shown by the superior results obtained from the crop of cocoons produced this year over those produced in 1886. It must not, however, be inferred that much does not remain to be done in this direction, for much may be gained by the establishment of purchasing stations which shall be feeders to the Washington filature, and where cocoons may be purchased when fresh and stifled and dried in large quantities and by improved methods. In fact, much surprise has been expressed by the French reelers at the results which we have obtained by the reeling of mixtures of many small lots stifled by many different processes.

There were purchased, of the crop of 1886, 1,513 pounds of cocoons, of an average value of 95½ cents per pound. Of these, 1,062 pounds were reeled and produced 260 pounds of silk, worth $4.75 per pound, while the remainder has been sold as waste at 50 cents per pound. From these figures it may easily be deduced that the experiments are not by any means paying expenses, but that is a result which can hardly be hoped for with a plant so small as that employed here. We hope, however, to gain, in another year's experience, indications of what could be done if working under factory conditions.

What leads me to be more hopeful in this respect is the fact that Mr. Serrell has so improved his reels as to do away with much of the hand labor incident to the apparatus which we are now using, this hand labor having been found extremely tedious and expensive. I have already perfected arrangements by which the Department is to be allowed to construct and operate some of these improved machines, and I am now having drawings of them prepared with this object in view. By their use it is hoped to double the output without increasing the force employed. These machines will probably have been put to a very thorough test before the publication of my next annual report, and I hope at that time to be able to make some definite statement regarding the probable success or non-success of the industry in the United States.

In addition to the experiments already recited, others have taken place at Philadelphia under the direction of the Women's Silk Culture Association of the United States, and a report thereon has been submitted to me, in accordance with law. This report will, pursuant to the direction of Congress, be transmitted to that body at the proper time.

DIVISION OF STATISTICS.

The work of collection and co-ordination of the facts of agriculture in this country and, in a more limited sense, throughout the world, has progressed successfully during the year. The application of statistics to business furnishes the balance-wheel which regulates its operations. It is the guide of the legislator, the counselor of the merchant, and the friend of the farmer. It suggests what to plant for profit and how much will fill the demand; it detects the erroneous practice and points out the more profitable method. Its uses in this division are in the interest of accuracy and truth, the improvement of American agriculture, cheaper production, and more economy in distribution.

The yearly development of agricultural statistics, under national authority and voluntary organization, throughout the world, is opening new fields for collection and enlarging the accumulating stores which furnish material for the use of this division. Much has been done during the past year in classifying and systematizing the records. A comprehensive plan of indexing statements and facts for easy reference is in operation, calculated to save much time that might be wasted in fruitless research, and increasing greatly the possibilities of prompt and efficient service.

The facts of agricultural production, foreign and domestic, in this as in former years, point to large yields where labor is high and economy compulsory, and low rate of production where land is cheap and abundant. It exhibits the anomaly of large production on old lands of moderate original fertility and small yields on rich and virgin

soils, and hints at rewards of skill and applied science and the punishment of negligent and superficial cultivation. One year with another, statistics show that the new lands of America and Australia yield per acre only about half as much as the sands of Holland and the English lands that have had centuries of cultivation, and that the richer the soil the swifter the decline in yield, in some cases, because weeds the sooner smother the wheat in the absence of cultivation. In accord with this fact, census and crop reports show a better average yield in the principal winter-wheat regions than in the spring-wheat districts, in the old lands than in the new, in the domain of rotation and fertilization than in that of primitive wheat-growing.

The effective force of this division usually includes about sixty persons in the Department, over twenty-three hundred county correspondents, each having at least three assistants, and State agents, with some thousands of their reporters. Our foreign service is under the direction, as heretofore, of Mr. E. J. Moffat, the deputy consul-general at London, who has authority to employ the consular resources of this Government in Europe, and the aid of European statisticians and experts in agricultural and commercial information, for the purposes of his statistical investigation, which relates primarily to those products in which the United States may have a competitive interest.

The printed reports of the division for the year include an annual report and eleven special reports, making about eight hundred pages. The miscellaneous manuscript reports, statements, and letters comprise thousands of manuscript pages.

The crop-reporting system of the Department is not a census, which would be an impossibility. The units of a crop can not be counted till grown, and a veritable count would be useless because too late. Crop reporting is counting in advance by instantaneous generalization. Is it worthless, as some pretend? Fortunately there are a few tests available. There is one crop, cotton, that is enumerated quite accurately. The record of the National Cotton Exchange furnished in September, 1887, of the actual growth of 1886 was 6,443,000 bales. The estimate of the Statistician of this Department was just 17,000 bales more, and that of the exchange 40,000 bales less. Either is a wonderfully accurate forecast. The Department estimate exceeded the recorded yield by seven ounces of lint per acre. For three years past the forecast has been nearly as close. The wheat estimates for six years make an average of 439,274,270 bushels; the consumption, on the basis of $4\frac{2}{3}$ bushels per capita, the actual exportation, and the seed, together required 440,735,346 bushels, showing an excess over estimates of nearly a fourth of a million bushels per annum. It may not be possible always to make so close a forecast; in the minor crops discrepancies occur; but the continued and pronounced success in the principal crops shows what can be ac-

complished under a system which is now coming into use throughout the world.

The production of the present year is not quite up to the average rate of yield. The crops which are notably deficient are corn and potatoes, both affected very seriously by the severe drought in the West. Cotton was also reduced by seasons characterized by great extremes of moisture and of inequality of temperature, which reduced vitality and decreased the rate of yield. Hay is another important crop which suffered from drought in a large district in the West, though abundant elsewhere. The cereals were generally harvested before the severity of the drought was felt, and made nearly average yields.

The indications of condition and rate of yield point to a corn crop of about 1,456,000,000 bushels. The area planted was expected in July to produce more than 2,000,000,000 bushels. Six of the past seven years have had crops under average. The average for 1881 to 1886, inclusive, was 24 bushels per acre, while that from 1878 to 1880, inclusive, was 27.6 bushels per acre. Though it is not probable that a periodicity of fat and lean years in corn production exists, this marked difference must be due to meteorological influences which it would be interesting and instructive to know definitely. The rapid increase of acreage, however, prevents a decrease of absolute product, the six bountiful years showing an average of 1,434,000,000 bushels, and the lean years making an average of 1,639,000,000 bushels.

The wheat yield is slightly below that of last year, but with increase of area the season will aggregate about 456,000,000 bushels. The oats crop amounts to 669,000,000 bushels. Barley, rye, and buckwheat are nearly medium crops.

The minor crops of the country have been generally productive in a moderate degree.

There has been a serious failure in potatoes, the product being about 134,000,000 bushels, at the rate of 56 bushels per acre, as low a rate of yield as has ever been reported, 1881 having nearly the same average.

The cattle of the country have been decreased by losses on the plains and in the mountains, and flocks of sheep are reduced from the discouraging effect of low prices, but the statistical position renders almost certain an increase in the value and profit of meat production.

An important feature in the current work in this division is the preparation of a series of charts and maps to show the geographical distribution and limitation of important crops. There has been frequent inquiry for such graphic illustrations in various lines of agricultural statistics, and it is very desirable to extend the work of the division in this direction.

Another line of statistical investigation of the highest importance, for which Congress is asked for a special appropriation, is a thorough statistical survey of the Territories and States of the Rocky Mountain region. There has been much done by the General Government to indicate the wealth of minerals beneath the surface, but nothing, except from the pittance available from the regulation appropriation, for collection of statistics of agriculture, for the description of the magnificent agricultural resources of this great continental area, and the exact results attained thus far in their development. Without it, a close approximation of the rapid changes occurring in the cattle husbandry, wool growing, in irrigation and other improvements, in the introduction of new grasses and various plants, can not be made. This region is destined to achieve a progress that few at present realize as a possibility. It is a district comparatively neglected, and reasonable complaints of such neglect are not unfrequently made.

I desire in this connection to make public acknowledgment of obligations, personal and official, due and gratefully tendered to the public-spirited and intelligent farmers who constitute the Department corps of crop reporters. They stand as a guard of honor over the interests of the great class which they represent, in opposition to reckless and irresponsible misstatement of crop prospects for private speculative purposes. They realize that the exact truth, if it can be ascertained, is best for the interests of all, and that an inaccurate statement destroys public confidence and recoils upon its prepetrators. They are deserving of the gratitude and respect of the nation for their freely given and unremunerated labors.

The Statistician of the Department of Agriculture, Mr. J. R. Dodge, a member of the International Statistical Institute, was designated as the representative of the Department, in accordance with provision made by the last Congress for such representation, at the first biennial meeting of the institute, which convened in Rome, Italy, on the 12th of April, 1887. This body was organized for the development of the progress of administrative and scientific statistics throughout the world, and is limited to 150 members, at present comprising little more than half that number. It seeks to secure greater uniformity in the schedules for statistical returns of different countries, to unify international methods in statistics, and to render comparable statistical results of different countries. It intends to prepare international publications in elucidation of statistical questions, and to invite the attention of governments to the questions to be solved by statistical investigation.

The Italian Government co-operated generously in making the sessions of the institute profitable and agreeable. The status of landed property, the methods of census enumeration, questions of economic and social statistics, and statistics of labor occupied a large

share of the time of the session, and work in several directions was initiated for the *ad interim* service of several committees.

A further commission was for the investigation of the methods of national bureaus of statistics, and a collection of all available published results of their work in Rome, Paris, Vienna, Berlin, The Hague, Brussels, and London. The time occupied, ten weeks, though too short, was sufficient for accumulation of much valuable information and large accessions to the official literature necessary for daily reference in the work of the division.

DIVISION OF CHEMISTRY.

The line of investigation undertaken by this division in food analysis and methods for the detection of food adulteration has been continued and supplemented, and now includes the following classes:

(*a*) *Dairy products.*—The investigations of the different constituents of milk and butter, and butter substitutes, have been continued, and the results have been published in Bulletin No. 13, Part I. A new apparatus for the determination of fat in milk has been tested and found to be exceedingly efficient, permitting a larger number of analyses to be completed with equal accuracy in less time than by any other method. This instrument is the lactocrite. It effects the separation by centrifugal force. From its simplicity and rapidity of manipulation it would form a valuable addition to the plant of large dairy farms, where it is desirable to perform a large number of tests in a day.

(*b*) *Spices and condiments.*—The work mapped out during the past year for an exhaustive examination of this very largely adulterated class of foods has been brought to a close and embodied in Bulletin No. 13, Part II.

(*c*) *Commercial fertilizers.*—As in the preceding three years, the Association of Official Agricultural Chemists received the hospitalities of the Department of Agriculture, and their fourth annual convention was held in the library of the Department during the past summer. The analytical methods and details of manipulation adopted by this body for the analysis of commercial fertilizers and agricultural products have been published in Bulletin No. 16, and some of the analytical experiments for verifying the methods adopted were performed by this division.

(*d*) *Fermented alcoholic beverages.*—Pursuing the investigation of foods and food adulterants, the scope of examination was extended to wines, fermented and malt liquors, and ciders. The report containing the analytical data and their discussion is now in press and will shortly be issued as Bulletin No. 13, Part III.

(*e*) *Coffee, tea, and chocolate.*—To ascertain the nature and extent of adulteration practiced in the preparation of the above-named articles for the market, a large series of analyses has been commenced,

and will be continued, and it is hoped that valuable data will be accumulated for future publication.

(*f*) *Baking powders and bakers' chemicals.*—An investigation into the composition and value of the various brands of baking powders found in our markets has been commenced, but the work is not yet sufficiently advanced to warrant any conclusions.

Sugar experiments, as in former years, have been extensively undertaken and require a detailed statement of work conducted at Fort Scott, Rio Grande, and Magnolia Plantation by the Department.

This statement will be published as a special bulletin.

The number of miscellaneous samples submitted during the past year has been exceptionally large, comprising waters, minerals, fertilizers, ores, lignites, analyses of plants and parts of plants, and many other articles of general or particular interest.

DIVISION OF BOTANY.

The work of the division of botany has been vigorously prosecuted during the year. Its correspondence is constantly increasing, relating to grasses, fibers and fibrous plants, medicinal plants and products, new species for cultivation, weeds and means of eradicating them. A bulletin concerning Southern grasses has been issued and widely distributed among Southern farmers and stock-growers. An investigation of the grasses and forage plants of the arid districts of Texas has been conducted by an agent, and a large amount of information has been obtained.

Another agent has performed a similar work in Arizona, Nevada, and Utah, making a collection of about two hundred species of grasses and forage plants having more or less agricultural value. Through these investigations our knowledge of the vegetation of the arid regions has been much increased, particularly in regard to those plants which have been found useful among stock-growers.

A question of the greatest importance for the arid districts of the West and Southwest is that of securing an increase in the grazing capacity of the lands through the introduction of new grasses and through cultivation. I desire first to obtain a thorough knowledge of the natural grasses and plants which are utilized by horses, cattle, and sheep, as to their abundance, choice of soils and locations, their size and vigor, and their comparative nutrition. Then there should be instituted in suitable localities a thoroughly conducted series of experiments with all the promising species of the region itself, and of such other kinds as have been found useful in similar locations in other countries. To this end I shall invoke the aid of the experiment stations connected with the agricultural colleges of the region interested. It is, however, a question whether more good would not

be accomplished in a shorter time in a few stations established for this express purpose.

There yet remains considerable territory to be explored with reference to the native grasses, and a continuation of the appropriation for grass investigation is earnestly recommended.

About 6,000 specimens of plants have been mounted and added to the herbarium during the year, and 36 packages have been distributed among agricultural colleges and institutions, and to individuals for exchange. The herbarium serves a double purpose. It is necessary for consultation and comparison in determining the names of specimens which are the subject of inquiry and investigation, and it is highly important in a scientific point of view, as being a repository of botanical specimens of the productions of the country. A large majority of all the known plants of this country are already represented in the herbarium. But it is still deficient in the plants of many sections, mainly in such kinds as are strictly local and restricted in their range and not obtainable through the ordinary channels.

For the past ten years there has been no botanical work performed in connection with the Government surveys. Previously it was the practice to have naturalists connected with the surveys and explorations, and the botanical collections made by them were finally deposited with the Department of Agriculture. In this way the herbarium was enriched, and a stock of duplicates for distribution was accumulated. Since the abandonment of natural history in the surveys, the enlargement of the herbarium has depended on a small annual appropriation for this purpose. There is now urgent need for more Government aid in the prosecution of botanical work. The Government herbarium should be made to contain a complete representation of all the plants known to grow within the limits of this country. It also needs the services of specialists in the elaboration of certain orders. Therefore, for its improvement in the directions mentioned, and to make it more useful to science and to practical agriculture, I recommend that the appropriations for this division be suitably increased and that an increase be made in the working force.

SECTION OF VEGETABLE PATHOLOGY.

To the section of vegetable pathology are referred for investigation all questions relative to the diseases of fruits and fruit trees, grains, and other useful plants, due to parasitic fungi, which are familiarly termed "rust," "smut," "mildew," "blight," "rot," etc. In accordance with my recommendations to Congress at its last session, this section was regularly established by law, provision was made for a chief of section, with an assistant, and a small appropriation, necessary for the prosecution of its work, was granted the Department.

Throughout the year the duties of the section have been carried forward energetically, and its published reports have met with the heartiest approval of fruit-growers and farmers. The constantly increasing correspondence of this section clearly demonstrates the appreciative interest taken in its work.

The report on the fungus diseases of the vine, referred to in my last report as being in preparation, was published in December, and its favorable reception by the public press and by grape-growers all over the country give assurance that it has been the means of accomplishing much practical good. The first edition of this report is now nearly exhausted, and I hope to be able to prepare a second and enlarged edition, which shall embrace the discoveries made during the present season and combine the results of the recent French investigations, both upon the diseases of the vine and the efforts which have been made in France to combat them.

During the present season the French Government has sent to this country a special commissioner for the purpose of investigating our methods of viticulture and the fungus diseases to which our vines are subject. All possible facilities for the furtherance of his work have been afforded this commissioner through the section, and the most cordial relations have been established between those now specially engaged in investigating diseases of the vine in France and in the United States, which will doubtless result in good to both countries. The chief of the section has visited the more important vine-growing regions of the United States, in company with the French agent, and a full and complete report covering the entire subject of vine diseases is expected as the result of the investigation made.

A new disease has appeared in the vineyards of California, and in response to requests for its investigation I have directed an agent to visit the infected districts and to investigate this malady, in the hope of protecting the vine-growers of the State from the threatened destruction of their vineyards.

Special experiments in the treatment of grape mildew and rot have been made in a number of vineyards especially selected for the purpose, with the view of determining the relative efficacy and cost of the several treatments suggested. The data thus gathered have led to some valuable conclusions, and will be of the utmost service in conducting future operations.

Early in the season a circular giving formulæ of the most approved remedies for mildew and rot of grapes was widely distributed, and many responses giving results of experiments have been received. It has been demonstrated by these operations that, in order to obtain the best results in experimenting with remedies, the work should be done immediately under the direction of a person thoroughly conversant with the nature and habits of the fungi to be treated, and who can remain in the field and daily watch the

results, and thus save time and obviate the danger of drawing false conclusions. One false deduction tends to destroy public confidence in all work of this kind. By securing, either through purchase or rental, a small vineyard, wherein experiments could be made under the immediate and constant supervision of a competent officer, the losses which might occur through some trials would not fall upon individuals, and all the results obtained could be published with that official warrant which would inspire the confidence of all interested. The extent of the losses occasioned by fungus parasites certainly calls for the exercise on the part of the Government of every possible effort to discover certain means for their destruction.

The question of the application of remedies has been a serious one, and doubtless some of the failures in the trials already made have been due to the use of improper methods. It was soon discovered that American machines for making the applications were far from satisfactory. They were either too cumbersome, or the labor involved was too fatiguing, or they were too wasteful of the materials used. For several years past special efforts have been made in France towards perfecting spraying appliances and bellows for the application of liquids or powders in combating the downy mildew of the vine by exhibitions and special premiums, resulting in the attainment of a high degree of perfection. Some of the most improved patterns have been imported for use in experiments. A report covering this branch of the subject is now in preparation.

Although many able papers have been published on the subject of peach yellows, and several observers have made careful scientific investigations of this very important but still obscure disease, the results so far obtained are far from conclusive as to its cause, possible remedy, or means of prevention. A special agent, to act under the direction of the chief of the section, has been commissioned to make a thorough investigation of this subject and to endeavor by every available means to settle beyond further doubt the questionable points. This work is progressing very satisfactorily, and extended investigations have been in progress since the 1st of July in eastern localities, where the orchards have suffered most from the disease.

Early in the year a circular of inquiry relative to facts bearing upon the subject of potato rot was distributed throughout the country, and the extent and value of the information gained thereby was most satisfactory. The work of compiling the information thus acquired has been completed, and this material will form the basis of a report on this subject now in preparation. A map has been prepared which shows the distribution and severity of the disease in all parts of the country for a given year.

Other papers in the report of the section for last year relate to certain fungus diseases of the vine and their treatment, celery-leaf

blight, orange-leaf scab, a disease of orchard grass, and pear blight. A report on the powdery mildew of the gooseberry, or "gooseberry blight," has been prepared and is nearly ready for publication. Arrangements have been made for a report on the "smut and rust of Indian corn." Throughout the season the section has been collecting material for a report on the apple-scab fungus, which is so widespread in this country and often does such damage.

DIVISION OF GARDENS AND GROUNDS.

The introduction, propagation, and distribution of desirable useful plants is a leading function of this division, in the exercise of which, since the organization of the Department, good results have been accomplished. It has distributed many things which have been of great and acknowledged value to the country, and the experience gained in testing the hardiness and other qualities of plants previous to their general distribution has been the means of acquiring useful preliminary knowledge of their requirements, so that the Department could judge with much accuracy the climatic conditions under which they will prosper.

The conditions necessary to their full utilization, independent of climate, are also closely studied, so that the requirements for ultimate success and the probabilities of failure are alike ascertained to a degree which prevents at least costly failures during the experimental process of testing the practicability of new or untried industries. Tea-plants are still propagated and distributed, although there is no present prospect of the profitable production of tea as an article of commerce. There are many reasons why tea-culture can not be made profitable here in competition with other countries where the conditions for success are more favorable; but the principal drawback is the want of sufficient rain-fall during summer, which prevents the continuous successive growth of succulent leaves. But there is no reason why the culture of a few plants, enough for domestic use, may not become general wherever the plant will endure the climate. It is the object of the Department to encourage tea-culture to this extent, as there is no uncertainty about securing a good spring crop of leaves wherever the plant flourishes. Lately a large number of plants have been distributed throughout the State of Florida, and where the plants have been set in moderately rich, moist soil their growth has been satisfactory.

The camphor tree of Japan is being distributed in the Southern States, but mostly in Florida, with the view of its employment as a shade and for planting as a protection for fruit orchards and groves. It is an evergreen tree, of rapid growth, and attains a considerable size. Its timber is of special value for certain purposes, such as for cabinets, where the presence of insects is not desirable, as they dis-

like the odor of the wood; and the sublimation of camphor from the branches and twigs may become a matter of experiment.

The efforts of the Department for more than twenty years have been directed to the introduction and popularization of the culture of Japan persimmons, and they have been successful in attracting the attention of commercial cultivators to the value of this fruit as a marketable commodity. Much interest is now felt in its production, and the demand for plants, formerly wholly supplied by the Department, is now fully met by nurserymen, who propagate the plants for sale.

The successful culture of the European grape has hitherto been limited to regions west of the Rocky Mountains and mainly near the Pacific coast line. Of late years vineyardists in Texas and Florida have been encouraged from the results of experiments made to enter more largely into the culture of the foreign grape. The Department has therefore propagated and has now ready for distribution a considerable number of plants of the best varieties of these grapes, with a view to render these experimental tests more general throughout the regions alluded to.

The demand for tropical and semi-tropical plants for experiment in the warmest portions of the Southern States increases with the population. Especially is this applicable to Florida, whence applications for numerous strictly tropical species are constantly received. The Department endeavors to meet all reasonable demands in this line, and has under process of propagation various plants which may ultimately prove useful in that State.

DIVISION OF ECONOMIC ORNITHOLOGY AND MAMMALOGY.

The work of this division during the past year, as heretofore, has consisted chiefly in the collection of facts showing the relation of birds and mammals to agriculture, horticulture, and forestry, and in the preparation for publication of two important bulletins, namely, (1) on the English sparrow, and (2) on bird migration in the Mississippi Valley. The general interest in these bulletins is shown by hundreds of applications for them received at the Department in advance of their publication.

As stated in my Annual Report for 1886, circulars and schedules asking for information in regard to the English sparrow were distributed by the division in 1885 and 1886. Replies were received from more than 3,000 persons. The information contained in these replies has been arranged for publication under seven different heads, as follows:

(1) Time and manner of first appearance of the English sparrow; present abundance and apparent rate of increase; kind and degree of assistance and protection afforded or withheld by man.

(2) Relation of the sparrow to other birds.

(3) Injury to trees or vines.

(4) Injury to fruits and garden vegetables.

(5) Injury to grain.

(6) Relation of the sparrow to injurious or other insects.

(7) Methods of restriction; suggestions for extermination; miscellaneous information.

The introductory portion of the sparrow bulletin contains a synopsis of the principal facts brought to light by the investigation, together with deductions from the same, and suggestions to legislative bodies and to the people in regard to the best methods of abating the sparrow scourge.

The collection of material relating to the destructive ravages of rice-birds has continued, and a few experiments have been made with live hawks for the purpose of frightening the birds from the fields. These experiments have been only partially successful, owing chiefly to the fact that the Department was unable to secure the services of an experienced falconer to train the hawks and take charge of the experiments. One fact, however, was demonstrated, namely, that rice-birds will not come near a live hawk, even when resting on a stake; and when in motion the hawk is effective at much greater distances than when at rest. There can be no question that hawks trained to fly about the fields would keep the rice-birds off, and the expense would be less than that of the present system of "bird minding."

The inquiry concerning the food habits of the crow, the various blackbirds or grackles, and several other species of special economic importance has resulted in the accumulation of so much information that special bulletins on these subjects will be published as soon as the material in hand can be properly arranged.

One of the most important branches of investigation undertaken by the division is the critical examination of the contents of stomachs, gizzards, crops, and gullets of birds. The elaboration of this material is a slow process, requiring much technical knowledge, as well as patience, on the part of the investigator. A single stomach sometimes contains representatives of several of the primary divisions of the animal kingdom. For instance, a hawk's may contain at one time the remains of a meadow-mouse, a sparrow, a snake, a frog, a grasshopper, an earth-worm, and a snail—representatives of the seven primary groups, mammalia, aves, reptilia, batrachia, arthropoda, vermes, and mollusca.

During the past year an assistant ornithologist has devoted most of his time to the study of the food material found in the stomachs of hawks and owls, of which the division now has upwards of five hundred. A brief statement of the contents of each stomach is made on a card prepared for the purpose, and these cards are arranged under species. The results of this investigation will be published in a special bulletin.

The expenditure of large sums of public money in bounties on mammals (known or supposed to be injurious) in several of the States and Territories attests the urgent need of the investigations now in progress in the Department upon the food habits and distribution of the various species and the best methods of destroying the injurious kinds. In Montana alone, during the present year, more than $50,000 was expended in bounties on prairie-dogs and ground-squirrels in about six months (from March 5 to September 12, 1887). It is stated that this bounty act exhausted the treasury and was running the Territory in debt, when the governor, with the permission of the President, called a special session of the legislature and repealed the law.

THE SEED DIVISION.

Very little need be said in reference to the work accomplished in the seed division, except to corroborate the fact that the reforms inaugurated at the beginning of my term of office have proved to be highly satisfactory, and judging from the unusual number of reports received, the seeds sent out during the present year have been exceptionally noticeable for their vitality and excellence of quality.

A more efficient system of reports has been adopted, and the replies indicate more fully than heretofore the special fitness of the numerous varieties for the localities in which the seeds have been tested. The system by which they are now purchased, a special guaranty being required from the parties from whom the purchase is made that the seeds shall not only be true to name, of good germinating quality, cleaned with extra care, so as to be both free from weed seed or eggs or larvæ of injurious insects, and the strict and close test to which they are subjected before payment is made for them, accords with the more perfect business system which has been adopted in the seed division.

The law establishing the Department of Agriculture clearly states that the purchase and distribution of seed shall be confined to such seeds as are "rare or uncommon to the country," or "such as can be made more profitable by frequent changes from one part of our own country to another." The primary object of the distribution is to give increased value to production, to ascertain the best geographical distribution of varieties, and to introduce them more rapidly into the localities to which they are best adapted. The value of this interchange of seeds is greatly underestimated. Every plant has a natural habitat, which is limited in extent, and it is an established fact that when an attempt is made to grow it elsewhere it soon deteriorates and requires renewal from seed grown under the conditions of soil and climate most favorable for its perfect development.

This is not only true of grain, but applies to a larger extent to garden vegetables. This statement is corroborated by the large

number of reports of experiments with the seeds sent out by this Department during the past two years. The remarkable yields reported must be mainly attributed to the use of fresh seed grown in localities where each variety attains its highest perfection.

A diminished production should not always be attributed to the deterioration of the soil alone, and the facts on record in this Department show that the introduction of seeds from regions where they attain the greatest perfection has been of much importance to the country. In no way is this fact so forcibly impressed upon farmers as by furnishing them such seeds, for they will then be convinced by personal experiment. Every farm upon which these seeds are tested becomes an experiment farm so far as that particular product is concerned, if the farmer is intelligent and of an observing turn of mind.

While only a small quantity of any variety of seed was formerly sent to one locality, now, instead of eight or ten varieties, not less than forty or fifty varieties are distributed in every Congressional district by the recently much improved system of distribution. The advantage of the test of so great a number of varieties must be apparent. By care on the part of the recipients to save and exchange among their neighbors seed of any choice varieties of grain or vegetables, the entire section of country can soon be supplied, and the increase in yield and quality may greatly enlarge the value of farm products.

Several new and valuable seeds have been introduced from foreign countries and distributed during the fiscal year ending June 30, many of which are likely to prove of great value to the agricultural interests; among these are Egyptian clover (*Trifolium alexandrinum*), procured through the United States consul at Cairo, Egypt, and which it is thought may be a valuable addition to our forage plants in certain districts which are subject to protracted droughts, as in the Southern and Southwestern States, and also in the arid districts of the West. The seed has been distributed to various farmers and experiment stations for trial, and the results are being awaited with much interest.

An effort has also been made to obtain seeds of some other forage plants having the same adaptation, first, of spurry (*Spergula arvensis*); second, of a kind of winter pea, said to be much cultivated in France; and third, of the lentil (*Ervum lens*), which is cultivated in the south of Europe. Wheat has also been received from Italy; red and white Bermuda onion seed from the Canary Islands; Abyssinian grass from the Royal Gardens, Kew, England; and potato seed from Belfast, Ireland. Several varieties of seed have also been received from the United States consuls in Mexico and distributed in the localities to which they are evidently the best adapted.

Many choice varieties of tobacco seed have been received by the Department from foreign consuls, and promptly distributed in local-

ities which were deemed the best adapted for their successful cultivation. Among these was a variety of Sumatra tobacco, which is attracting unusual attention and is eagerly sought by those who are actively engaged in increasing the area devoted to tobacco culture in Florida.

I desire again to call attention to the fact that Congressional lists should be furnished not later than December 15.

The seeds designed for distribution by members of Congress and to statistical correspondents, experiment stations, and agricultural societies in the Gulf States, Arizona, New Mexico, and California should be sent out not later than the middle of December of each year.

The hearty co-operation which now exists between the seed division and the botanical, forestry, and the other divisions has been productive of results which, if continued, will do much to promote the practical value of each to the farmers throughout the entire country.

EXPERIMENT STATIONS FOR TESTING AND DISTRIBUTING SEED.

While I have endeavored to secure the greatest practical benefit to the farmers of the country under existing laws as they relate to the seed distribution by the Department, yet it is my opinion that the object aimed at could be better secured through the experiment stations that were provided for by law at the last session of Congress. It will be remembered that a bill was passed providing for an annual appropriation of $15,000 for the benefit of the experiment station of each State and Territory in the United States. The object of these stations is to experiment with seeds, plants, crops, fertilizers, systems of culture, etc., and to determine what is best for their respective State or Territory. The directors of such stations ought to know which kinds of seeds the farmers of their State are most interested in, which are best adapted to each locality, what crops are most profitable to raise, and to direct their investigations and experiments and selections to such kinds as their constituencies are most interested in.

These stations are under the control of scientific and practical men, assisted by skilled laborers. Careful records are kept in every line of work, and the comparative merits of different varieties as to thriftiness, hardiness, productiveness, and general adaptation to the climate and soil are ascertained and published, and are considered authoritative. With a little additional aid to these stations, if not already sufficiently provided for, to purchase seeds and plants and test the same for their respective localities, and to distribute the seed from the same after ascertaining which are of real value to farmers, a most beneficial work for the farmers of every State could be accomplished. The stations could do the testing and experimental work for the whole body of agriculturists, and do it much better than

farmers with but poor means for conducting such experiments. If this work of testing and distributing seed could be done by the stations and the Department be relieved of this duty, it would enable it to work in other directions of great importance to the agricultural interests of the country. It is hardly necessary to state that it takes much of the time of the Commissioner, and that it is difficult to make distribution to give satisfaction to all parties and to all parts of the country. While the germ of the Department of Agriculture was the seed distribution, it has grown until it now reaches into many fields of science, and many more lie beyond which as yet it has not had the time or means to enter.

FORESTRY DIVISION.

The limited appropriation available for this division naturally limits the field of its activity and the extent of its usefulness. Our people do not realize yet the importance of its work. There is scarcely an industry with which other industries of the country are more intimately connected than that which utilizes and manufactures the products of the forest, nor is there any other factor of climatic influences within the power of human regulation more important than the forest cover. The undeniable interdependence between forestry and successful agriculture calls for timely attention on the part of the people, and especially of the Government.

The idea of considering forest products as a crop, which, like other crops, can be cared for, improved, and reproduced, is still so new in our country that it seems difficult to persuade our people of its importance. When we consider the fact that this crop requires from twenty to one hundred years to mature, and that the sower rarely reaps the harvest, the comparative indifference of the grower and the need of stimulating reproduction are apparent. The original growth is being exhausted, and the new spontaneous crop, through the fault of man, is greatly inferior and smaller from the same area. Increasing needs of enlarging population can only be satisfied by proper care of the new crop and by increasing the crop area.

Those engaged in the lumber industry and wood-using manufactures appear to be more or less unconcerned about their future supply, either because their interests are ephemeral, or because they lack a definite knowledge of total present demand and total visible supplies. With information as accurate as that in regard to other crops, prices for wood material would quickly rise to a level more adequately representing true values. In consequence, supplies would be better husbanded, more carefully protected, and more thoroughly utilized, and we would soon regard the forest as a valuable "heritage, not for spoil or to devastate, but to be wisely used, reverently honored, and carefully maintained."

The division has collected during the last year information in regard to the minor wood-using industries, and several reports are on hand for future publication.

Bulletin No. 1, on the relation of railroads to forest supplies and forestry, has found a most gratifying attention and interest among railroad managers, and I am glad to see, from the demand for this publication, that an important class of business men of the community have become interested in the subject and seem to derive tangible benefit from the work of the division.

I urged in my last report the necessity for the Government to revise its legislation in regard to the forest lands remaining in its hands, especially in the mountain regions of the West. I repeat, that the present state of affairs works injury, increasing every year, to the mining as well as the agricultural interests of the country adjoining those mountain forests, and the special forest legislation recommended is demanded by the people of those regions. To serve as a basis for such legislation, an exhaustive report on the forest conditions of the Rocky Mountains has been prepared by the division and is about to be issued as a separate bulletin.

In the absence of experimental grounds, without an arboretum, and without the aid of forest areas upon which to conduct directly practical experimentation, the work of the division must consist mainly in collecting, sifting, and arranging information found scattered through our literature, and adding to it what may be elicited by correspondence. The study of the biology of our timber trees by expert agents is being continued, the reports upon the most important conifers being nearly ready for publication. These studies, if systematically and thoroughly carried on, would give answer to many questions of practical forestry.

While we may go on gathering opinions, a reliable basis for forest management can only be derived from exact methods of investigation. To establish the rate of growth of the different species under different conditions, upon which alone a true estimate as to their adaptability for profitable forest culture can be formed, numerous measurements must be made, which are expensive. The field of inquiry is large, the number of available expert observers limited, and the means for this work lacking.

Another most important line of inquiry which calls for special attention from the division are investigations into the structural differences of our important timbers, and the factors influencing their quality. Lacking this knowledge, a good deal of useful material is wasted, either by being applied to purposes for which inferior material might have been employed or by remaining unused when it might have been usefully employed.

The distribution of plants has been mainly confined to coniferous trees, which, while most important in forest growing, do not find

favor with the larger class of planters, on account of the care they need in transplanting and in raising from seed, and, therefore, encouragement in that direction is most needed. I have tentatively inaugurated a system by which I can supply seedlings directly from the nursery, thus insuring better success than could be obtained by trusting the seeds to unskillful treatment.

A considerable correspondence, in replies to inquiries, occupies much of the time of the office force of the division and aids in enlarging the interest in the subject. Thus, the division, while struggling to do justice to its technical needs, is called upon also to carry on a missionary work, in keeping that interest in the forestry question alive and growing without which a reform in the forest policy of our country can not be expected. I most earnestly commend this question to the careful consideration of Congress, and recommend such legislation as is demanded by the importance of an interest which foreign governments have long since recognized in their administrative policies, and liberally provided for.

DIVISION OF MICROSCOPY.

The work of this division for the current year has been confined chiefly to microscopical investigations relating to the crystallography of butter, oleomargarine, and butterine, and, for purposes of comparison, the fats of wild and domestic animals.

The object of these investigations, primarily, was the discovery of a ready means of detecting butter substitutes, of whatever description, as manufactured or sold in violation of law; and this the Microscopist claims to have successfully accomplished.

This investigation of butter and fats has attracted wide-spread attention and interest, which have consumed an important part of the time of the division in answering inquiries, furnishing information, etc., and have led to new fields of exploration. Examinations are now being made in order to ascertain whether the butter crystals of imported and registered breeds of milch cows, or of pure breeds but not entitled to registry under the rules of any association, so differ one from the other that they may be distinguished by means of the microscope under polarized light. The feed of the respective animals, in connection with the seasons, is also taken into consideration in these investigations. In some cases marked differences are said to be observed, and the Microscopist will endeavor to illustrate these in a forthcoming report.

The investigation of the forms of the fatty crystals of animals other than milch cows may prove of interest, from a point of view other than that connected with their possible relation to butter; and a knowledge of the forms and other peculiarities of the crystals of the solid fats used in medicinal preparations and in the arts and manufactures may also prove of great value as a means of detect-

ing adulterations in them. A large number of photographs of such crystals have been successfully made, showing in many cases marked divergencies of form. At first great difficulty was experienced in portraying some of the important details of these crystalline bodies, and other difficulties presented themselves in the reproduction of the photographs by any of the photo-mechanical processes known, but in consideration of the great interest manifested in this new scientific work, both in the United States and in Europe, a number of artists engaged in photography and photo-mechanical reproduction of photography have each endeavored to excel in the production of illustrations of this work, and it is hoped that a process of reproduction has been discovered which will enable us to fairly represent them and lead to a better understanding of these crystalline types than has heretofore been possible.

In addition to the work on these investigations, the Microscopist has been largely called upon to make examinations of butter for the general public and for wholesale and retail dealers in pure butter who frequently send samples to this division for examination before a purchase is made.

Dealers in oleomargarine have in like manner submitted samples for examination, their object being to protect themselves and the public against inferior goods of this kind.

The result of an investigation of palm fibers, undertaken by the division in the interests of a branch of the Navy Department, will appear with illustrations in the forthcoming annual report.

There have also been examined during the year the ultimate cell-structure of the following class of fibers: Combed manila hemp, pure manila yarn, Sisal hemp, pure Sisal twine, pure Mauritius aloe, Mauritius aloe hemp, and New Zealand hemp. This work was undertaken at the request of merchants, for the purpose of detecting fraudulent sales of mixed fibers of this character.

Illustrations of their respective forms are in preparation, and will be photographed for public purposes. While the fibers have a general similarity of form, differences in their respective diameters and in the angles of their terminal points may afford a means of discriminating between them.

Other investigations have been made in emergency cases, such as the examination of cream-puffs, confections, ice-cream supposed to have been poisoned, milk, drinking water, etc.

A large correspondence has also been carried on with persons in various parts of the United States, Canada, and in European countries, in answer to inquiries relating to the general work of the Microscopist.

POMOLOGICAL DIVISION.

This newly established division is subserving well the purposes for which it was organized, and there is abundant evidence that the as-

sistance which it is affording to the fruit-growers of the country in stimulating and promoting our pomological industry is timely, and that there was need of the establishment of such a branch in the Department. The division is now well under way, and it only needs a requisite encouragement to make it a successful and powerful auxiliary to the Department, and to give it a position commensurate with the interests which it is supposed to foster. I am glad to note that the division is receiving that co-operation from our fruit-raisers and from our leading pomological writers which is so desirable in the early days of organization. I believe that the division has been inaugurated under favorable auspices, and I commend its future to the careful consideration of Congress.

There are statistical and practical facts to be gathered for information; there are new fruits to be found and distributed; there are varieties to be investigated and their characteristics described; there are fruits in one section which may be introduced into another section with profit; there are methods of culture, of pruning, of general training of fruit trees to be set forth; there are mistaken ideas of sites for fruit orchards to be corrected; there are varieties of fruits to be classified; the nomenclature of fruits requires attention and study; and, in general, there is a vast quantity of valuable information to be spread abroad.

The farmer who in these days of competition in one branch of agriculture turns his attention to another product of the farm as a source of profit is obeying an economic instinct and keeping step with the march of progress. Happily, this idea of diversification leads many into the line of fruit-growing. This desire to found an orchard on the farm, this purpose to produce fruit in greater abundance, should be encouraged in every way, and the latest and best information should be at hand for guidance in right paths and for warnings as against wrong ones.

A great many inquiries of a pomological nature have been received from farmers and other citizens of the country and answered by direct correspondence where the reports of the Department would not give them the requisite information, and this work is steadily increasing in volume.

Packages of specimens of fruits have been daily received for identification or for comparison and study. These demand, and have received, the personal attention of the Pomologist, and the increasing amount of this work requires a corresponding increase of assistance. The real service already rendered in this direction is considerable, although it has only just begun.

Accurate records and descriptions are made and kept of all specimens received, and in many cases drawings and colored illustrations are made of such varieties as are new or of special importance. These are used for publication in the reports of the division, or are

kept for future reference. This work is of so much importance that the constant services of a skilled artist are necessary, and I hope to have funds appropriated for that purpose.

The progress already made and the encouraging prospects for future usefulness are evidences of the wisdom of the establishment of this division.

THE DAIRY.

The work upon matters pertaining to this branch of the Department has been prosecuted during the year, but under discouraging conditions. The desire has been to obtain data sufficient to make comparisons of the several averages of production in the dairy States and sections. I regret to find an indisposition, however, on the part of those engaged in this great industry to respond with alacrity to our requests for information. The dairymen in every section are seeking individually what the Department can not supply, because of the lack of unity of interest among them as a class, in the efforts of the Department to secure statistics and facts of interest in this line of industry.

The Department will continue the investigation in this direction for a short time longer, in the hope that the above suggestion will result in a willingness on the part of those interested to devote the required time and impart the desired information for the benefit of the whole. Otherwise I shall abandon the investigation.

GRAPE AND WINE PRODUCTION.

During the year there has been instituted inquiries into facts and figures relative to the grape and wine production of the country. Several circulars have been prepared, and fifteen thousand distributed among those engaged in these twin industries. I am encouraged to believe that this information, which will supplement that published by the Department some years ago, will be fairly complete to date and prove valuable to all concerned.

TEA.

In accordance with the provisions of law, the interests of the Government at the tea farm in South Carolina have been closed out during the year, the property has been properly disposed of and accounted for, and, in accordance with the terms of the lease, the custody of the farm has reverted to its owner.

ILLUSTRATIONS.

Science and art have reduced the question of illustration to a practical and economical solution, and it has become a valuable and almost indispensable adjunct to modern writings. There are now employed in the Department skilled draughtsmen and an engraver,

in order that their work may be constantly under supervision, in its every detail, by those of our scientists who wish to illustrate their thought, their discoveries, or their work.

A single illustration, covering but a small part of a page, will often bring a subject clearly before the mind of man, where many pages of text and of figures would fall far short of making the vital point easily comprehended. The illustrations prepared by the Department appear in its various reports, and so far they are of incalculable value. But they contain information oftentimes which should be more widely disseminated than is possible through those reports. I therefore urgently recommend that the Public Printer be given authority and means to furnish to the agricultural press of this country, at the mere cost of the labor and material, electrotypes of such of the illustrations of this Department as may seem to the respective editors interesting and valuable to their readers.

It seems to me entirely proper that such action should be taken, as it would result in a wide and also prompt dissemination of information, now almost entirely confined to our editions, and hence their value is confined to a necessarily limited circulation.

Our printing fund is small. Five thousand copies is usually the utmost limit of an edition of a special report. The supply falls far short of the demand in very many cases. Surely the plan I recommend would be the equivalent of a large edition; it would popularize the Department more and more, it would familiarize the people with what we aim to do, it would stimulate thought, it would promote the habit of closer observation; and, in short, it would greatly benefit those who receive little tribute at best in proportion to the part they assume in the progress, prosperity, and welfare of the country.

LABORATORY.

I renew my recommendation for the erection on the grounds of the Department of a laboratory, apart from the main building, and suitably equipped for the great number of scientific experiments annually conducted here, and for the purpose of entering into other fields which need investigation and can not be entered for want of facilities. The need of this building is most imperative; the Department's force and duties grow from year to year, but no adequate provision is made for the necessary space to keep pace with this natural and healthy development.

The business of the Department has now to be transacted, for the most part, in a small, illy-ventilated, inconvenient building, which is little else than a fire-trap, in which public papers and valuable records and property are intrusted. In the basement of such a building is the chemical laboratory of this Department, damp, inconvenient for the purpose, dark, and unhealthy, and in the attic of the building is located the only laboratory for the investigation of animal

diseases that our space will afford. The clerks above the basement are subject at all times to the sickening odors which proceed from chemicals and chemical analyses below, and are subject as well to the additional source of danger from fire and explosion; and because of the presence of these clerks in the building it is impossible to investigate in the laboratory in the attic some of the common diseases of animals which are contagious and dangerous to human life.

LIBRARY.

Every year since the establishment of the Department Congress has annually appropriated money for the maintenance of the libary, for the completion of series, and for the purchase of scientific and other works, and yet the space for the storage of this vast and valuable collection remains the same as it was twenty years ago. A well-equipped library, systematically arranged and properly conducted, is an imperative necessity to any scientific institution—it is the fuel to the fire. For years the Department's works have been crowded into a room too small for the purpose, with no suitable place for preservation from insects and dust or against loss and confusion, always in anticipation that it would be deemed wise on the part of Congress to relieve a condition of affairs here which in ordinary business would be corrected without delay. I have been compelled to recognize these dangers, and in order to better systematize the library and to protect valuable public property, much of which can not be replaced, I have removed the museum objects from exhibition in the main building to another portion of the grounds, and am now engaged in removing the library to that floor, where it will have abundant room for many years to come. With a new laboratory building, and with this change, the Department will be temporarily relieved of the present pressure for room, though the erection of a new and properly arranged Department building of a less inflammable character than the present one would still seem to be the part of wisdom.

WOOL AND COTTON.

It is gratifying to note that the report on wool, to which I referred in my first annual report, has been printed, and is now in process of distribution. It is an elaborate, valuable, and interesting report. In this connection I beg to renew the recommendation made in my last report relative to an incomplete and unpublished investigation upon the subject of cotton, of similar tenor and purpose. In response to a demand that other fibers than wool should be studied, the Department in 1883 and in 1884 caused to be collected for investigation a series of samples of cotton, as follows:

(1) Cotton produced under different known conditions of seed, soil, climate, and culture in all parts of the great cotton belt of the United States;

(2) Representative cotton from the different commercial grades of the several cotton markets;

(3) Cotton from different stages in various processes of manufacture.

The examination related to the length, fineness, strength, and elasticity, upon all of which the value of the staple depends. There have been some $5,000 already expended in this examination, and I am assured that $7,500 more will complete it. In view of the importance of this investigation, both to the producer and to the consumer of this great staple, it seems that the money already expended ought to have some return, and inasmuch as the total expense would be insignificant when compared with the results, I renew my recommendation of last year for authority and means to complete the work.

IRRIGATION.

Among the documents that have been prepared by the Department and printed directly by Congress is one on "irrigation," which has been completed during the present administration. This report, although fairly complete in itself, is principally suggestive of more comprehensive treatment of the subject in the future, as projected works are completed and more general extension of irrigation systems have been accomplished. The present work is already attracting wide-spread attention in those sections of our country where irrigation is relied upon.

Such extension, it is well understood, is limited by the amount of water available. It is true that as the cultivated soil receives the precipitation, however small the quantity, that formerly flowed over the impacted surface without penetration, the amount of irrigation necessary is lessened, and the application of water by irrigation further modifies the chemical and hydroscopic character of the seed-bed until less and less moisture is annually required. It is a reasonable supposition that ultimately some portion of the area now useless without irrigation may be productive with only the usual rain-fall, which has proved insufficient heretofore. At least it may be expected that certain plants which thrive with minimum supplies of moisture may be cultivated successfully without irrigation in favorable locations, as the result of soil ameliorations by cultivation with temporary irrigation. Thus the ultimate extension of available tillage or meadow, through the labor of man and the bounty of nature, is difficult to foretell, and will doubtless greatly exceed the popular estimate. Then the adaptation of plants to these areas, so greatly modified in their capabilities, will offer a wide field for selection of profitable crops and for the successful introduction of many plants now unknown to our agriculture or grown to a limited extent.

When available supplies of water are exhausted there is still a resource that should command the early consideration of Congress—

the building of reservoirs among the mountains for the storage of an immense volume of water which is now wasted in spring floods, causing, in part, the spring rise in the Lower Mississippi, sometimes so disastrous. Thus would the resources of the cultivators of the Rocky Mountain slopes be doubled, and the destruction of hundreds of thousands of acres of corn and cotton be obviated by the same beneficent measure, attesting its utility as well as its nationality and constitutionality.

FOLDING ROOM.

The following is a statement showing the number and kinds of documents received at and distributed from the folding room of the Department.

The Annual Report of the Department for 1886 has been printed during the current year, by order of Congress, 400,000 copies in number, of which 375,000 are held for distribution by Senators and members of the House of Representatives, and 25,000 copies assigned to this Department.

The Report of the Bureau of Animal Industry for 1886 has been printed during the current year, by order of Congress, 35,000 copies in number, of which 30,000 are held for distribution by Senators and members of the House of Representatives, and 5,000 copies assigned to this Department.

The report on wool and other animal fibers has also been printed during the current year, by order of Congress, 10,000 copies in number, of which 9,000 are held for distribution by Senators and members of the House of Representatives, and 1,000 copies assigned to this Department.

Other reports have been as follows:

DIVISION OF STATISTICS—NEW SERIES.

	Number.
No. 36. Report on the crops of the year and on freight rates of transportation companies, December, 1886	15,000
No. 37. Report on the numbers and values of farm animals, the cotton crop and its distribution, and on freight rates of transportation companies, January and February, 1887	16,000
No. 38. Report on the distribution and consumption of wheat and corn, on the wheat production of the world, etc., March, 1887	15,000
No. 39. Report on the condition of winter grain and farm animals, and on freight rates of transportation companies, April, 1887	15,000
No. 40. Report on the condition of winter grain and progress of cotton planting., etc, May, 1887	16,000
No. 41. Report on the acreage of wheat and corn, and on freight rates of transportation companies, June, 1887	16,000
No. 42. Report on the acreage of corn, wheat, and tobacco, with condition of growing crops, etc., July, 1887	16,000
No. 43. Report on the condition of growing crops and on freight rates of transportation companies, August, 1887	16,000

No. 44.	Report on the condition of crops in Europe and America, and on freight rates of transportation companies, September, 1887	16,000
No. 45.	Report on the condition of crops, yield of grain per acre, labor prices in Mexico, and freight rates of transportation companies, October, 1887	16,000
No. 46.	Report on yield of crops per acre and on freight rates of transportation companies, November, 1887	16,000
No. 47.	Report on the crops of the year, and on freight rates of transportation companies, December, 1887	16,500

There have been printed and sent to county correspondents eleven monthly circulars of 11,000 each, or 121,000, in the division of statistics, and monthly circulars to State agents aggregating 33,000.

BOTANICAL DIVISION.

		Number.
Bulletin No. 2.	Report on fungus diseases of the grape vine	5,000
Circular No. 4.	Treatment of the potato and tomato for the blight and rot	15,000
Bulletin No. 3.	Report on grasses of the South	5,000
Bulletin No. 4.	Desiderata on herbarium of North America	500
	Report of the Botanist for 1886, October, 1887	1,000
	Report of the Mycologist for 1886, October, 1887	500

CHEMICAL DIVISION.

Bulletin No. 13.	Food and food adulterants—Part I, dairy products	10,000
Bulletin No. 13.	Food and food adulterants—Part II, spices and condiments	5,000
Bulletin No. 13.	Food and food adulterants—Part III, fermented alcoholic beverages	5,000
Bulletin No. 14.	Experiments in the manufacture of sugar from sorghum at Fort Scott, Kans., February, 1887	10,000
Bulletin No. 15.	Experiments in the manufacture of sugar at Magnolia Station, Lawrence, La., May, 1887	5,000
Bulletin No 16.	Methods of analysis of commercial fertilizers, feeding stuffs, etc	3,000

POMOLOGY DIVISION.

Bulletin No. 1.	Condition of tropical and semi-tropical fruits in the United States	10,000
Bulletin No. 2.	Condition of Russian and other fruits	25,000
Circular No. 1.	For the purpose of procuring reliable information of the grape-growing and wine-making industry of the country	15,000

ENTOMOLOGICAL DIVISION.

Bulletin No. 10.	Our shade trees and their insect defoliators, May, 1887	5,000
Bulletin No. 13.	Observations and experiments in the practical work of the division, May, 1887	3,000
Bulletin No. 14.	Reports of observations and experiments in the practical work of the division, August, 1887	3,000
Bulletin No. 15.	Report on the Icerya or fluted scale, August, 1887	3,000
Bulletin No. 16.	Entomological writings of Dr. Alpheus Spring Packard, October, 1887	3,000
Report of Entomologist of 1886, October, 1887		300

DIVISION OF ORNITHOLOGY.

	Number.
Bulletin No. 1. Report on the English sparrow	10,000
Bulletin No. 2. Bird migration in the Mississippi Valley	4,000
Report of the Ornithologist for 1886, July	500

DIVISION OF FORESTRY.

Bulletin No. 1. Report on the relation of railroads to forest supplies and forestry, together with appendices on the structure of some timber ties, their behavior and the cause of their decay in the road-bed; on wood preservation, on metal ties, and on the use of spark arresters, October, 1887	5,000
Report of forestry division for 1886, August, 1887	1,300

MISCELLANEOUS REPORTS.

Addresses of Hon. Norman J. Colman, U. S. Commissioner of Agriculture, and Dr. D. E. Salmon, Chief of the Bureau of Animal Industry, delivered before the National Cattle Growers' Convention held at Kansas City, Mo., October 31 and November 1, 2, 1887	5,000
Special 11. Proceedings of a convention of delegates from agricultural colleges and experiment stations, held at the Department of Agriculture October 18, 19, and 20, 1887	10,000
Report on irrigation in the United States	1,000

MISCELLANEOUS WORK OF THE FOLDING DIVISION.

Folding of letter jackets	25,000
Envelopes made, 10 by 14	600
Franks written	98,940
4,760 packages of envelopes and 2,580 quires of paper mailed to correspondents	7,340
Number of letters written	595

For the hearty co-operation which I have received from the chiefs of divisions of the Department; for the conscientious devotion to public duty which has characterized the record of its clerks; for the unyielding fidelity to its every interest which they have displayed, and for the efforts of all who have contributed to the progress of its administration, I desire to express my acknowledgments.

The history of another year, here briefly summarized, is to me a gratifying exhibit. It remains for another branch of Government to deal with the future of the Department as shall seem to redound to the benefit of our people and the wisest development of our agriculture.

Very respectfully, your obedient servant,

NORMAN J. COLMAN,
Commissioner of Agriculture.

REPORT OF THE ENTOMOLOGIST.

INTRODUCTION.

SIR: I have the honor to present herewith my annual report for the year 1887. Much is omitted therefrom, both on account of restrictions as to the size of the volume and the increased number of the divisions of the Department which must be represented in the general report, and on account of the policy which I am more and more adopting, with your sanction, of confining the publication of articles of less general interest, or rather those upon insects affecting the more restricted crops or industries, to the special bulletins of the Division. The chief articles in this report, therefore, treat of two insects which are found throughout the country and which affect seriously several of our most important crops.

The entomological event of the year has been the great damage done by the Chinch Bug in most of our grain-growing States of the West. Mr. Dodge, the Statistician, reports that at the very lowest estimate the loss for the year has amounted to $60,000,000 in nine States. Owing to the fact that Bulletin 5 of the U. S. Entomological Commission treated of the species with some detail, and to the further fact that I have dealt with it fully in my earlier writings, especially while State Entomologist of Missouri, no complete account of it has been published by the Department. There is so much that is new to investigate and work at that I find it difficult to dwell at length on insects to which I have given so much time in the past. The bulletin just mentioned is, however, out of print, and the demand for information on the subject is so constant that I have had Mr. Howard prepare as the first article of this report a complete account of the species. The article not only digests all that has been published, but includes a number of unpublished facts, mostly derived from the observations of the field agents of the division. The only new remedy of importance brought into use since the publication of the Missouri reports, viz, the kerosene emulsion, is here treated in some detail.

Much the same reasons may be given for the publication of the second article of the report,, which has also been prepared by Mr. Howard. The Codling Moth is the most injurious of our orchard pests, and a complete summary of its habits and remedies is needed. Recent experiments have shown the value of arsenical spraying, if done carefully and at the right time, and more space is therefore devoted to the consideration of this remedy than to the others.

An account of the investigation of the Hop Aphis, mentioned in the Introduction to my last report, is deferred for a few months. The investigations made have been thorough and satisfactory, and justify, in a striking manner, the position taken a year ago. The

hibernation upon Plum in the egg state, the migration therefrom in spring to Hop, and the return migration in the fall have been fully proved in the States, and I have had the privilege of going over and verifying the same facts in the hop-fields of England, during the furlough which I took from the office last fall on account of continued poor health. The experimentation in the way of remedial measures against its attack have also been most successful and satisfactory. The results of the investigation are of such importance and interest that I have been unable to put them together and prepare the necessary illustrations for this annual report, and for these reasons they will appear in separate bulletin form in the spring. In the same way the results of the continued investigations of the Buffalo Gnats, concerning which a preliminary article was published in my last report, are held for future publication.

The work of the Division in carrying out the provisions of the law for the establishment of silk-culture in the United States has entailed quite as much labor during the past fiscal year as in previous years, and the results obtained have been quite as satisfactory as could have been expected under the circumstances. The general scope of the work has included the distribution of Silk-worm eggs and books of instruction and the conducting of experiments with automatic silk-reels, as mentioned in previous reports. The sixth edition of the manual of instructions, "The Mulberry Silk-worm," consisting of 3,000 copies, which was issued in May, 1886, has been practically exhausted and a more enlarged edition is now in the course of preparation. The public interest has centered in the filature, which has been visited by large numbers of persons who uniformally express delight at the experiment. For a full statement of the working of the filature and for other details in reference to the work in silk-culture I refer to the accompanying report of Mr. Walker.

Experiments upon the Fluted or Cottony Cushion-scale of California and the other injurious scale-insects of that State have been continued during the season, and results from the two agents detailed for this purpose are included in this report. To Mr. Coquillett, of Los Angeles, was assigned the duty of experimenting with gases. His report, giving the results of a long series of careful experiments, will prove of interest to the people of California. One of the principal discoveries made by Mr. Coquillett is the fact that hydrocyanic acid gas, when passed through sulphuric acid, is rendered harmless to the foliage of trees confined in it. This will greatly lessen the cost and labor of treating trees with this gas. The experiment with tobacco stems vaporized, an account of which will be found near the end of this report (experiment 128), is worthy of further investigation. Another gas that gives promise of being successfully used as an insecticide is arseniureted hydrogen, which would have the advantage of cheapness as compared with hydrocyanic acid gas; but additional experiments are necessary before its claim can be fully established.

It should always be borne in mind, both in the use of this gas and the hydrocyanic acid gas, that the ingredients are exceedingly poisonous, and the greatest care should therefore be taken by the operator. The history of similar cases of destructive insects introduced from other countries goes to show, however, that the introduction of the natural enemies that keep the Fluted Scale in check in its native country will prove more effective than any other methods in subduing the pest and at the same time relieve the fruit-growers of the large expense attending the employment of even the most satis-

factory remedies. The injuries of this Icerya have so seriously affected the fruit interests of southern California that the leading fruit-growers, in convention assembled, have earnestly petitioned Congress to give you the power to have the natural parasites and enemies of the insect in its native country studied and imported. I have not a doubt that much practical good would result from the study of these parasites in their native country and their introduction to southern California. It would be particularly appropriate to make an effort in this direction in 1888, because of the International Exposition at Melbourne in which this Government will take part. The exposition, in many ways, would further the investigation referred to and asked for by the people of California. The expenses would be trifling if one of the salaried agents of the Division could be employed therefor; but the clause in the appropriation which restricts traveling expenses for the Division of Entomology to the United States precludes the sending of any one without some special law, and I earnestly call your attention to this fact.

Mr. Koebele, stationed at Alameda, has experimented chiefly upon other scale-insects, and he has found that arsenious acid in one form or another is a valuable addition to the kerosene, emulsified with resin compound, as I suggested it would prove to be in my address before the State Board of Horticulture at Riverside last April (see Bulletin No. 15, Division of Entomology). In every instance where the arsenic was added the result was a complete extermination of all scales. He has also obtained excellent results in the application of the dilute resin compound against Plant-lice, including the destructive Woolly Aphis of the Apple (*Schizoneura lanigera*). In the proportion of one part of the compound to eight parts of water it was found that the lice were killed without injury to the beneficial Syrphus larvæ or to the internal parasites of the lice.

The report published from Prof. Herbert Osborn, of Ames, Iowa, relates to some of the more important insects of the season in Iowa. The Turf Web-worm (*Crambus exsiccatus*) has been particularly abundant, and the report contains a good account of its life history and injuries. The Wheat-head Army-worm, the False Chinch-bug, and the injurious Blister-beetles are also treated of. Prof. Osborn has also sent in a report upon the Chinch Bug (which has been used by Mr. Howard in the general article on the subject), and a report upon observations on Hop insects in Wisconsin, which is reserved for future use. He has also continued to assist me in work on the parasites of domestic animals.

Mr. Bruner's report treats of the damage done by the Chinch Bug in Nebraska, of the condition of the migratory and non-migratory locusts or grasshoppers, and of other less important insects of the season.

Mr. Webster, in addition to an extended report of his observations during the earlier part of the season on the Southern Buffalo-gnat, has submitted some other observations, which are here published. These refer in the main to corn-insects.

These reports as a whole, together with the correspondence of the Division, indicate that, aside from the Chinch Bug and a very few local outbreaks of other species, the year has been one of comparative immunity from insect injuries.

The apicultural experiment station has been changed in location from Aurora, Ill., to Hinsdale, in the same State, the latter location possessing advantages in the way of convenience of transportation

and in other ways. The experiments of the year have been continued on the lines suggested in my last report, and the agent in charge submits in his report the results of his investigations of two important bee diseases, and continues his account of experiments on the control of reproduction.

The colored plates accompanying the report were drawn and colored by Miss Sullivan, under Mr. Howard's supervision.

Respectfully submitted, January 30, 1888.

C. V. RILEY,
Entomologist.

Hon. NORMAN J. COLMAN,
Commissioner.

THE CHINCH-BUG.

(*Blissus leucopterus*, Say.)

Order HEMIPTERA; family LYGÆIDÆ.

[Plates I and III.]

By L. O. HOWARD, *Assistant.*

INTRODUCTORY.

The present treatment of the Chinch Bug offers little scope for anything new or original. It is an extremely destructive species, which has been exhaustively treated by former writers, and which, after several years of comparative scarcity, has again become very injurious, so much so as to occasion the loss of millions of dollars during the present season and to call forth the greatest variety of comment from the press of the country, agricultural or otherwise. In this emergency it happens that there are no public documents for distribution and even no books which can be purchased which treat of the life history of and remedies for this pest. The State reports of Riley and LeBaron are out of print; the small edition of Bulletin 5 of the U. S. Entomological Commission, by Dr. Thomas, was long since exhausted, and the recent bulletin and circular by Forbes treat almost solely of remedies.

It becomes necessary, therefore, to bring out once more a complete review of the subject; and in the accessible form of this report, 375,000 copies of which are printed, it will undoubtedly receive wide distribution. Previous writings, particularly those of Riley, are freely used, and in many instances the well-known Missouri reports of my chief are quoted at length. Professor Riley's scraps and notes, as also the notes in the Division of Entomology, have been at my disposal.

PAST HISTORY.

It has been quite generally accepted, that the Chinch Bug is, comparatively speaking, a Southern rather than a Northern insect, and in so far as the matter of destructive appearances goes this idea is well upheld by its past history. In our section upon geographical distribution, however, we have shown that the species is by no means confined to the more Southern States, but that it is often found north

of the boundary line in Canada. It was first noticed, so far as we can find, in North Carolina at the close of the Revolutionary war, where, as has has been so often stated, it was mistaken for the Hessian-fly, which at that time was attracting considerable notice on Long Island and thereabouts.

Dr. Fitch, in his second report, gives at some little detail an account of its early appearances, from which we may simply state that after this first notice the insect did considerable damage for several years in North Carolina, South Carolina, and Virginia. After a short series of seasons it was again destructive in North Carolina in 1809, so that in Orange County the cultivation of wheat was abandoned for two years.

In 1839, in the same States, great damage was done to corn and wheat, and in 1840 an increase in number occurred and the wholesale destruction of the crops was only prevented by an exceedingly wet season.

The first scientific description of this species was given by Say in 1831, in a little pamphlet published at New Harmony, Ind., entitled "Descriptions of new species of Heteropterous Hemiptera," from a single specimen collected on the eastern shore of Virginia, and it was probably at that time rare in Indiana where Say resided, at New Harmony.

It attracted much attention in 1840 in Illinois, when it occurred in numbers in Hancock County, where it was supposed to have been introduced by the Mormons, and was called in consequence the "Mormon louse."

According to Professor Riley the first recorded appearance of the insect in Missouri was in 1839. It was again noticed in 1844 and has been destructive ever since. In Iowa its first recorded appearance is in 1847; in Indiana in 1854, and in Wisconsin in 1885.

1864 was a year marked by damage in these Western States. In 1868, a season of great drought, much damage was done by the bugs in Missouri.

In 1871 great damage was done in Illinois, southern Iowa, in parts of Indiana, in Nebraska, in southern Missouri, and Kansas. It was estimated by Dr. LeBaron, in his Second Illinois Report that the loss to the wheat, oat, and barley crops during this year amounted to $10,500,000 in Illinois alone, and in the other six States mentioned, including Indiana, the total loss was upwards of $30,000,000.

In 1874 they occurred again in Missouri and the adjoining States in exceptional abundance. It was during this season that Professor Riley sent out circulars to all parts of Missouri, and at the close of which he wrote the extended article which was published in his Seventh Missouri Entomological Report.

He estimated the total loss to the group of States of which eastern Kansas forms a center to be double that of 1871. Very careful estimates by counties give an aggregate loss of $19,000,000 for Missouri alone, including only the three staple crops of Wheat, Corn, and Oats. He mentions several facts which tend to show that this estimate is low rather than high.

From 1874 to 1881 there were no serious irruptions of this pest, but in this year it attracted considerable notice and did a great deal of damage in the same Western States. Much newspaper literature concerning the insect was published during this year, much of which was excited by Thomas's paper upon the relation of meterological conditions to insect development and particularly to the Chinch Bug.

It was during this year also that the "Chinch Bug convention" was held at Windsor, Kans., and it was decided to exclude wheat from cultivation as a means of extirpating the pest.

In 1882 the work of the bug upon timothy grass was discovered in Saint Lawrence County, N. Y., for the first time in its history. It increased and spread in 1883, exciting great alarm, and occasioned several articles from the pen of Dr. Lintner, who also issued a circular on remedies and anticipating further damage.

Professor Riley, in Science (Vol. II, p. 620), and in his report for 1884 stated that there was little cause for alarm in New York, and, indeed, no particular damage has since been recorded. In 1885 some damage was done in parts of Kansas and Nebraska, and in 1886 still more. Bulletin No. 13 of the Division of Entomology contains reports of considerable damage in the spring of 1886 from Kansas, Indiana, Ohio, and Nebraska, and more especially in southern Illinois.

GEOGRAPHICAL DISTRIBUTION.

East of the Rocky Mountains the Chinch Bug seems to be indigenous North and South, feeding naturally upon various species of wild grasses and becoming multiplied wherever the cultivation of wheat has reached its original haunts.

It was first noticed, as stated in the last section, in North Carolina, and Say's original description was published from a Virginia specimen.

Fitch records the fact that he had collected specimens in New York, but that it was exceedingly rare. Signoret also records it from New York, and, as we have just shown, it appeared in 1883 in destructive numbers in the northern part of this State. Harris, in the first edition of his well-known work, states that it did not occur in New England; but in a foot-note to his second edition states that while the sheet was passing through the press he discovered a single specimen in his own garden at Cambridge (June 17, 1852), and in 1883, according to Dr. George Dimmock (Psyche. Nov., Dec., 1883, p. 119), the lowland between Belmont and Cambridge was swarming with them. They have also been collected by Dr. Packard at Salem, Mass., in Maine, and at the summit of Mount Washington in New Hampshire. Dr. Lintner records the fact that Mr. H. L. Fernald captured one or more specimens in 1879, 1880, and 1882 at Orono, Me.

In Canada they occurred at Grimsby, Ontario, in 1866, and were sent from that point in that year to Mr. Walsh. Mr. W. F. Harrington collected specimens found abundantly at Sidney, Cape Breton (N. lat. 46° 18′), in September, 1884 (Can. Ent., Nov., 1886, p. 218).

Dr. Fitch received specimens from western Pennsylvania, and also stated that it was sent him from Mississippi with the information that in some years it damaged the crops of Indian corn. We have found it personally in considerable numbers in the rice-fields near Savannah, Ga., and Mr. E. A. Schwarz and others have collected it in Florida. In the latter State Mr. Schwarz found it very abundantly at Biscayne Bay, breeding in the wingless form only, in considerable numbers upon sand oats (*Uniola paniculata*). It has also been collected in this same form upon the same plant on the sea-shore at Fortress Monroe, Va., by Messrs. Schwarz and Heidemann. Mr. Webster has noticed it in Mississippi and Louisiana and Professor Riley has seen it in most of the Southern States. The States, however, in which it does the greatest damage are Virginia, North Caro-

lina, South Carolina, Ohio, Indiana, Kentucky, Tennessee, Illinois, southern Wisconsin, Iowa, Missouri, Kansas, and Nebraska. Uhler records the species from Texas, California, Kansas, Nebraska, Wisconsin, Minnesota, Illinois, Michigan, and generally throughout the Atlantic region.

Outside of the United States it is recorded only from Cuba (see Signoret, "Essai Monographique du Genre Micropus, Spinola," Ann. Soc. Ent. France, V, 3d series, 1857, p. 31), and the Cuban individuals are long-winged, while Mr. Schwarz never found a long-winged individual in Florida, in spite of the fact that he has collected in localities the insect fauna of which is in the main Cuban. This observation conflicts with the general observation of Mr. Uhler that the short-winged form seems to be more common in New England than in the Southern States.

The only authentic record of the occurrence of the Chinch Bug west of the Rocky Mountains is the mere mention by Uhler, in his List of the Hemiptera of the Region west of the Mississippi River (Bull. Hayden Surv., I, 306), of California as one of the States which it inhabits, but this record has been overlooked by Californians. Its advent upon the Pacific slope has been expected and dreaded. Matthew Cooke, in his book published in 1883 upon injurious insects of the orchard, vineyard, etc., figured and described it, and under the head of "remedies" wrote: "Should this pest appear in this State it can be prevented, etc."

In June, 1885, there were several newspaper reports on the occurrence of this insect in great numbers in California. The San Francisco Evening Post for June 23, 1885, quoting from the Woodland Democrat, published the statement: "Messrs. Frazee and Henderson, who live southwest of Woodland, brought to this office a bottle of this pestiferous insect (Chinch Bug) on Tuesday. Mr. Henderson says that he recognized them as the same Eastern variety that frequently does so much injury to wheat in Missouri. These gentlemen say they discovered the bugs traveling between the lands of Day and Clanton. There are millions of them, but as to the extent of country covered they are unable to say. The bugs are nearly grown and are just beginning to have wings. As soon as the wings develop they fly and scatter everywhere. Mr. Frazee says there is no danger from them this year as the grain is too far advanced." So far this item seems very plausible, but it goes on to state "that another gentleman had noticed them injure grape-vines," which, of course, introduces a probability of wrong identification.

There is no question, however, but that the Chinch Bug is to be found at present in California, but not the certainty of its existence in injurious numbers. Our certainty as to its presence arises from the fact that a single specimen of a short-winged variety of this insect is among a lot collected in the vicinity of San Francisco in 1885 by Mr. Koebele. It is unquestionably a true Chinch Bug. Another specimen of the same variety was collected in 1884 by some students of Johns Hopkins University, who summered in California, and was given to Mr. Lugger, of this Division, who was at that time connected with the university. Recent communications from California, in answer to inquiries on this point, show that the insect is not known to the entomologists in that State. The False Chinch-bug (*Nysius angustatus*) has been, we learn from Mr. Koebele, very destructive to Grape in that State the past season, and it is more than likely that this is the insect referred to in the newspaper article just

quoted. Mr. Koebele writes that the False Chinch was so abundant around Alameda in July that in an old road at least fifty specimens could be found under each plant of *Polygonum aviculare*. He made in 1887 a most careful search of the locality in which he found the 1885 specimen, but could not find a single additional individual. He also examined the large collection of Hemiptera in the California Academy of Sciences without success. The following paragraph is from Mr. Coquillett's answer to our inquiries:

"I have never met with the Chinch-bug in any part of California that I have visited—neither in Merced County, around the city of Sacramento, nor on the southern part of the State, where I have collected Hemiptera extensively with the sweep-net. Dr. Rivers, curator of the museum at our State University, writes me that three years ago he took three specimens of a bug that that looked much like the Chinch Bug, but was darker and smaller, and he does not believe that they belonged to this species; they were taken in Sonoma County and were sent off he knows not where. He has collected Hemiptera extensively since then, but the Chinch Bug is not among them. Mr. Wickson, editor of the Pacific Rural Press, writes me that he has 'never seen a specimen nor heard of one as being recognized by an observer whom I would consider as capable of recognizing the insect.'"

Since writing the above we have learned from Mr. Uhler that he has seen specimens of the Chinch Bug from California of a long-winged form which were collected near San Francisco, probably by Mr. Hy. Edwards. He has also seen specimens from Cuba and from Tamaulipas, Mexico.

INJURY DURING 1887.

During the present year (1887) the injury was marked in these States and also in some parts of Missouri, but the interesting point in the history of this season has been the occurrence of the insects in great numbers in portions of Virginia and North and South Carolina for the first time in many years, although no considerable damage has been reported to the Department. As a review of the localities and damage this season is desirable we publish a statement by Mr. J. R. Dodge, the Statistician of this Department, who has kindly prepared it at our request.

Mr. Dodge reports as follows:

"In accordance with your request, I take pleasure in communicating the results of inquiries made relative to the geographical distribution of Chinch-bugs during the past season, and to the extent of their destruction of growing crops.

"I find indications of their presence throughout the Southern and Western States, but no material injuries to crops are reported except in States bordering on the Mississippi River and the lower Missouri. Kansas, part of Nebraska, Missouri, Iowa, Illinois, southern Wisconsin, and eastern Minnesota include, practically, the field of their serious operations.

"They attacked wheat and rye first, then barley and oats, and afterward corn, grass, millet, sorghum, and broom-corn. As corn, wheat, and oats are the principal tilled crops of this area, they represent the principal part of the damage.

"In many places the fields were cleared, and small grain areas were plowed up. The pest came in some cases to districts that

had never before been ravaged; in many others the scourge was claimed to be more sweeping than ever before.

"The insect was present in injurious numbers in nearly every county in Kansas. Correspondents in Leavenworth, in the extreme east, and Hamilton, on the Colorado border, gave the only negative replies. The worst damage was done in this State.

"The infliction was general in Missouri except in a belt in the central part of the State, not very regular nor wholly untouched, trending northeasterly and connecting with a similar belt in Illinois.

"Further north, no portion of Iowa was exempt except the northwest corner of the State, in proximity to areas of exemption from central Minnesota westwardly through Dakota, and near to a similar area in northern Nebraska. In eastern Minnesota and southern Wisconsin, however, the scourge was general and severe. In Illinois comparative exemption was enjoyed in a central belt running in a northeasterly direction from Christian to Champaign, and from Adams to Bureau, fifteen to twenty counties, in which correspondents responded in the negative as to their destructive presence. Elsewhere the pest was nearly universal.

"The southwestern corner of Indiana was alive with Chinch-bugs; elsewhere, though present in much of the area, only about a dozen counties estimated any material losses. They were still scarcer in Michigan. Only ten counties in Ohio reported their injurious presence; and a few only in Kentucky indicated material damage.

"These insects are reported as more or less injurious in every season of drought and scarce or absent in all wet areas. They have attacked almost every crop, though giving their preference to the cereals. In the area of their depredations, the crops have an annual value of more than a fourth of the entire agricultural production of the United States, and a value nearly four times as great as that of the cotton crop. It will readily be seen that the losses must be heavy, undoubtedly greater than those of all other insects together, as no such values are involved in other crops subject to insect depredations the past year.

"The following table has been prepared from data severely scrutinized, revised, and accurately consolidated. It makes a large sum, and yet does not comprise all the damage done to barley and rye, millet, etc., all of which might be approximately stated in round numbers as $60,000,000. The record by States is as follows:

States.	Corn.		Wheat.		Oats.	
	Bushels.	Value.	Bushels.	Value.	Bushels.	Value.
Kentucky	983,280	$521,138	66,678	$48,675	....	....
Ohio	885,564	425,071	215,370	161,528	60,196	$19,263
Indiana	1,785,000	803,250	453,936	326,834	167,658	48,621
Illinois	16,929,600	6,941,136	5,529,150	3,870,405	3,810,310	1,028,784
Wisconsin	1,804,250	757,785	3,004,490	1,922,874	1,742,750	487,970
Minnesota	2,169,720	802,796	9,074,750	5,354,103	2,438,160	633,922
Iowa	22,020,240	7,707,084	6,977,620	4,256,348	4,462,920	1,071,101
Missouri	15,504,390	5,736,624	1,664,640	1,032,077	795,860	206,924
Kansas	16,840,340	6,230,926	2,282,100	1,392,081	6,406,560	2,438,497
Total	78,922,384	29,925,810	29,268,734	18,364,925	19,884,414	5,935,082

Accompanying these statement of Mr. Dodge were nine State maps indicating the counties reporting to the Department damage from

the Chinch Bug. Many other localities had Chinch Bugs in abundance, and considerable damage was done in States not represented in this list. These localities, however, are authoritative, and their reports furnished the main basis for the table which preceeds. We may summarize these briefly as follows :

Illinois, fifty-one counties, as follows: Stephenson, Winnebago, Lake, Carroll, Lee, Kendall, Will, La Salle, Rock, Mercer, Warren, Stark, Iroquois, Vermilion, Edgar, Douglas, Coles, Moultrie, Shelby, Cumberland, Clark, Jasper, Effingham, Fayette, Bond, Madison, Macoupin, Greene, Pike, Jersey, Saint Clair, Clinton, Washington, Marion, Clay, Lawrence, Wabash, Edwards, White, Hamilton, Franklin, Randolph, Jackson, Williamson, Saline, Gallatin, Johnson, Pope, Hardin, Massac, and Alexander.

Indiana, twenty-five counties, as follows : Elkhart, Jasper, White, Huntington, Wells, Blackford, Jay, Warren, Montgomery, Wayne, Shelby, Johnson, Sullivan, Greene, Dearborn, Knox, Martin, Ohio, Gibson, Pike, Dubois, Posey, Vanderburgh, Warrick, and Spencer.

Iowa, sixty-one counties, as follows: Winnebago, Worth, Mitchell, Howard, Winneshiek, Allamakee, Clayton, Fayette, Chickasaw, Floyd, Cerro Gordo, Hancock, Palo Alto, Pocahontas, Humboldt, Franklin, Dubuque, Buchanan, Grundy, Hamilton, Webster, Calhoun, Sac, Crawford, Carroll, Greene, Story, Marshall, Tama, Benton, Linn, Jackson, Clinton, Scott, Muscatine, Iowa, Jasper, Dallas, Guthrie, Audubon, Shelby, Madison, Mahaska, Keokuk, Des Moines, Henry, Monroe, Lucas, Union, Adams, Montgomery, Mills, Fremont, Page, Taylor, Decatur, Wayne, Appanoose, Davis, Van Buren, and Lee.

Kansas, sixty-three counties, as follows: Cheyenne, Rawlins, Norton, Phillips, Jewell, Washington, Marshall, Nemaha, Brown, Wyandotte, Jefferson, Jackson, Shawnee, Douglas, Pottawatomie, Riley, Wabaunsee, Davis, Clay, Cloud, Mitchell, Rooks, Graham, Sheridan, Thomas, Sherman, Gove, Russell, Lincoln, Ottawa, Ellsworth, Saline, Dickinson, Morris, Osage, Franklin, Miami, Linn, Anderson, Coffey, Chase, Marion, McPherson, Rice, Barton, Rush, Ness, Lane, Scott, Ford, Pawnee, Stafford, Reno, Sedgwick, Allen, Neosho, Cherokee, Labette, Chautauqua, Cowley, Sumner, Barbour, and Comanche.

Michigan, five counties, as follows: Manitou, Presque Isle, Saginaw, Shiawassee, and Saint Joseph.

Kentucky, eight counties as follows: Carroll, Pendleton, Bracken, Estill, Mercer, Union, Ballard, and Marshall.

Minnesota, twenty-seven counties, as follows: Hubbard, Wadena, Todd, Crow Wing, Kanabec, Pine, Isanti, Chisago, Sherburne, Stearns, Wright, Carver, Scott, Rice, Wabash, Winona, Olmstead, Dodge, Steele, Waseca, Watonwan, Martin, Faribault, Freeborn, Mower, Fillmore, and Houston.

Missouri, sixty counties, as follows: Atchison, Nodaway, Holt, Worth, Gentry, Harrison, Mercer, Putnam, Sullivan, Adair, Linn, Clinton, Caldwell, Ray, Chariton, Randolph, Lincoln, Saint Charles, Callaway, Cooper, Johnson, Cass, Bates, Henry, Saint Clair, Hickory, Osage, Maries, Gasconade, Franklin, Jefferson, Washington, Saint Genevieve, Perry, Iron, Bollinger, Cape Girardeau, Mississippi, New Madrid, Butler, Wayne, Oregon, Shannon, Pulaski, Laclede, Wright, Douglas, Ozark, Christian, Webster, Dallas, Hickory, Polk, Cedar, Dade, Barton, Lawrence, Barry, Newton, and McDonald.

Ohio, ten counties, as follows: Defiance, Wood, Geauga, Allen, Shelby, Darke, Franklin, Fairfield, Meigs, and Gallia.

FOOD PLANTS.

The Chinch Bug will feed upon all grains and grasses so far as known. The most prominent crops which are seriously injured are Wheat, Barley, and Indian Corn. The testimony in regard to Oats is conflicting, but LeBaron's conclusion to the effect that "if this grain be sown where Chinch Bugs abound, and especially if it is sown exclusively it will be damaged to a greater or less extent the first year, but that the bugs will probably not continue to breed in it to any great extent in succeeding years," is unquestionably correct. Broom-corn, Sorghum, Chicken-corn, Hungarian grass, Millet, Rye, rice, Bermuda-grass (*Cynodon dactylum*), Fox-tail grass (*Setaria glauca*), Timothy (*Phleum pratense*), Blue-grass (*Poa pratensis*), Crab-grass (*Panicum sanguinale*), Bottle-grass (*Setaria viridis*), *and*

all of our wild grasses, so far as known, are attacked, but beyond these no plant is ever damaged. Reports of damage done to other crops, such as grape-vines and garden crops, are the results of mistaken identity, and an error in the compilation of Packard's Guide to the Study of Insect has doubtless done much to perpetuate the idea that this insect is a more general feeder. This was corrected in the later editions of this work, probably at the suggestion in Professor Riley's criticism in his Seventh Rept. Ins. Mo., page 26.

Upon the Sand Oats (*Uniola paniculata*) in Florida Mr. Schwarz noticed that the entire development of the insect is undergone upon the highest part of this tall plant, and not close to the bottom as in our latitude. The probable reason for this, as he has pointed out, is that the strong winds are continually blowing fine, sharp sand through the lower parts of the plants, rendering it impossible for the bugs to remain at these places and forcing them to seek their nourishment higher up.

Concerning Timothy and the Crab-grasses Professor Forbes says: "It seems to prefer Timothy to Blue-grass, not really relishing either as a general thing, and takes to the Crab-grasses (*Panicum*) not at all, or only as a last resort" (Bull. No. 2, State Ent. Ill.). This generalization is undoubtedly correct for Illinois and the surrounding States, but, as Professor Forbes himself points out in a foot-note, the bugs did great damage to Timothy in northern New York in 1883, and the following extract from a letter recently received from Professor Atkinson, of North Carolina, indicates that in that State at least the Crab-grass becomes an important item of the insects' diet: "* * * I have recently discovered that at this season of the year (October) the Chinch Bug feeds on the 'crab-grass,' so common in cultivated and waste places, and especially so abundant in many of the corn-fields after cultivation has ceased. The Chinch-bug must go to the grass after the corn becomes mature and no longer yields the sap. I have found the bugs inside the sheath and clear evidence of their having punctured the colon. No doubt this grass affords them subsistence for quite a period of time, and then shelter for the winter. * * * I have found within the past few days pupæ, or wingless individuals, in the Crab-grass. * * *" Referring again to Timothy, we may state that a meadow of this grass on the farm of J. F. Whiton, near Wakeman, Huron County, Ohio, was injured considerably by the bugs in 1886. Professor Forbes, however (Bull. 2), gives an instance where sowing Timothy with fall wheat was probably the cause of the salvation of the crop.

On cultivated Rice we found Chinch Bugs very generally scattered throughout the large rice-fields near Savannah, Ga., in August, 1881. Only adult specimens were found at that time, and all were fully winged and were found upon the heads of the grain, to which they had probably flown, as the fields had been flooded for some time previously. No particular damage to the crop was perceptible, unless their punctures contribute to bring about the disease known as "white blast," as suggested by Professor Riley in his Annual Report for 1881–'82, p. 137.

We shall probably be obliged to widen our close restriction of the Chinch Bug food plants, to admit at least one of the Polygonums. A chance statement by Mr. Bruner that he had known this insect to feed upon the so-called "Wild Buckwheat" in Nebraska led to a letter of close inquiry, to which he replied that there can be no mistake and that the plant is either *Polygonum dumetorum,* or *P. convolvulus.*

STAGES OF GROWTH—DESCRIPTIVE.

The following descriptive matter is from Professor Riley's Seventh Report on the Insects of Missouri, and is fuller and more careful than that published elsewhere. It will be noticed that there are three larval stages, necessitating two molts before the pupa and three before the adult. It will also be noticed that the larvæ have but two joints to the feet, while the adults have three:

THE EGG (Plate I, fig. 2). Average length 0.03 inch, elongate-oval, the diameter scarcely one-fifth the length. The top squarely docked and surmounted with four small rounded tubercles near the center. Color when newly laid, pale and whitish, and translucent, acquiring with age an amber color, and finally showing the red parts of the embryo, and especially the eyes toward the tubernacled end. The size increases somewhat after deposition, and will sometimes reach near 0.04 inch in length.

LARVAL STAGES.—The newly-hatched larva is pale yellow, with simply an orange stain on the middle of the three larger abdominal joints. The form scarcely differs from that of the mature bug, being but slightly more elongate; but the tarsi have but two joints (Fig. 4, *d*), and the head is relatively broader and more rounded, while the joints of body are sub-equal, the prothoracic joint being but slightly longer than any of the rest. The red color soon pervades the whole body, except the first two abdominal joints, which remains yellowish, and the members, which remain pale. *After the first molt* the red is quite bright vermilion, contrasting strongly with the pale band across the middle of the body; the prothoracic joint is relatively longer, and the metathoracic relatively shorter (Plate I, fig. 3). The head and prothorax are dusky and coriaceous, and two broad marks on mesothorax, two smaller ones on metathorax, two on the fourth and fifth abdominal sutures, and one at tip of abdomen are generally visible, but sometimes obsolete; the third and fourth joints of antennæ are dusky, but the legs still pale. *After the second molt* the head and thorax are quite dusky and the abdomen duller red, but the pale transverse band is still distinct; the wing-pads become apparent, the members are more dusky, there is a dark red shade on the fourth and fifth abdominal joint, and, ventrally, a distinct circular dusky spot covering the last three joints (Plate I, fig. 4).

PUPA (Plate I, fig. 5).—In the pupa the coriaceous parts are brown-black; the wing-pads extend almost across the two pale abdominal joints, which are now more dingy, while the general color of the abdomen is dingy gray; the body above is slightly pubescent, the members are colored as in the mature bug, the three-jointed tarsus is foreshadowed, and the dark horny spots at tip of abdomen, both above and below, are larger.

IMAGO (Plate I, fig. 6).—The perfect insect has been well described, and I will append the original descriptions:

"Lygæus Leucopterus (Chinch-bug). Blackish, hemelytra white, with a black spot.

"Inhabits Virginia.

"Body long, blackish, with numerous hairs. Antennæ, rather short hairs; second joint yellowish, longer than the third; ultimate joint rather longer than the second, thickest; thorax tinged cinereous before, with the basal edge piceous; hemelytra white, with a blackish oval spot on the lateral middle; rostrum and feet honey-yellow; thighs a little dilated.

"Length less than three-twentieths of an inch.

"I took a single specimen on the eastern shore of Virginia.

"The whiteness of the hemelytra, in which is a blackish spot strongly contrasted, distinguishes this species readily." (Say, Am. Entomology, I, p. 329).

The above description originally appeared in 1832, in a pamphlet entitled "Descriptions of new species of Heteropterous Hemiptera of N. A."

"Length, 1⅜ lines, of three-twentieths of an inch. Body black, clothed with a very fine grayish down, not distinctly visible to the naked eye; basal joint of the antennæ honey-yellow; second joint of the same tipped with black; third and fourth joints black; beak brown; wings and wing-cases white; the latter are black at their insertion, and have near the middle two short, irregular black lines and a conspicuous black marginal spot; legs dark honey-yellow; terminal joint of the feet and the claws black." (Dr. William LeBaron, in the Prairie Farmer for September, 1850, Vol. X, pp. 280, 281, where the name of *Rhyparochromus devastator* is proposed for it).

Dr. Fitch also enumerates the following varieties of this insert:

(*a*) *immarginatus*.—Basal of the thorax not edged with yellowish. Common.

(*b*) *dimidiatus*.—Basal half of the thorax deep velvety black, anterior half grayish. Common.

(*c*) *fulvivenosus*.—The stripes on the wing-covers tawny yellow instead of black.

(*d*) *albivenosus*.—Wing-covers white, without any black marks except the marginal spot. A male.

(*e*) *apterus* (Plate I, fig. 7.—Wingless and the wing-covers much shorter than the abdomen.

(*f*) *basalis*.—Basal joint of the antennæ dusky and darker than the second.

(*g*) *nigricornis*.—Two first joints of the antennæ blackish.

(*h*) *femoratus*.—Legs pale livid yellow, the thighs tawny red. Common.

(*i*) *rufipedis*.—Legs dark tawny red or redish brown.

To these varieties, all of which occur with us, I would add one which may be known as *melanosus*, in which the normal white of the wings is quite dusky, and contains additional black marks at base and toward tip, and in which all the members and the body except the rufous hind edge of thorax are jet black.

In addition to these varieties mentioned by Dr. Riley, an interesting form has been collected by Mr. E. A. Schwarz, at Lake Worth, Fla., and by Mr. O. Heidemann, at Fortress Monroe, Va. This variety is illustrated on Plate I at Fig. 8, and is at once distinguished from other short-winged varieties by its more slender and pointed wing-pads and by the color of the antennæ, the first three joints of which are honey-yellow, while the last joint or club is nearly black. It seems also to be more thickly clothed with silvery pile, but this is probably due to the fact that the specimens studied were mounted dry, while all others which I have seen have evidently been placed in alcohol. This variety, so far as we know, has been collected on the sea-shore only.

NUMBER OF BROODS AND HIBERNATION.

For many years there existed a misconception concerning the number of broods of this insect in the West. It was always understood that there was more than one brood, and some newspaper writers insisted that there were as many as five or six annual generations. Professor Riley, in the Practical Entomologist, Vol. I (March 26, 1866), was the first to publish the definite statement that the Chinch Bug is two-brooded in northern Illinois, and Dr. Shimer, the succeeding year, published the same statement from his own observations. This number of annual generations holds through the entire Northwest and as far south certainly as the latitude of Saint Louis. Thomas states that there is some evidence of an occasional third brood in the extreme southern part of Illinois and in Kentucky, but that it is not sufficient to justify him in stating it as a fact, or to satisfy him of its correctness. In North Carolina there seems no question but that the second generation gave birth to still a third, which, as we are informed by Professor Atkinson, of Chapel Hill, was found in a half-grown condition on Crab Grass about the 1st of October. This third generation probably hibernates in the adult condition.

The Chinch Bug passes the winter in the perfect state. As cold weather approaches most of the full-grown bugs leave the hardened corn-stalks or wild grasses upon which they have been attempting to feed and seek some convenient shelter in which to pass the winter. They collect in fence cracks, in sheds, hay-stacks, straw-stacks, corn-shucks, under leaves, mulching, and rubbish of all kinds upon the ground, under the loose bark of adjacent trees, in stumps and logs, under stones and clods of earth, in fact, in any situation which will

offer shelter. They seem to prefer dry situations. Bunches of old dead grass and weeds offer them particularly attractive places for hibernation. Professor Atkinson writes us that the Crab Grass in North Carolina not only affords the bugs sustenance after the corn-stalks harden, but also gives them shelter for the winter, as they work their way down between the leaf-sheath and the stalk. Mr. J. O. Alwood writes us from Columbus, Ohio, that October 26, 1887, he observed them lying torpid within the leaf-sheaths of an uncut field of Pearl Millet. During cold weather they remain torpid. On a warm, sunshiny day they will stretch their legs and begin to move about to a slight extent; but as the cold becomes severe they press back deeper into their hiding-places. They can withstand the severest cold, and, in fact, as with so many other hibernating insects, the more sustained the cold weather the more the insects winter successfully. An instance is related by a reliable correspondent of Dr. Thomas in which the bugs frozen into ice were thawed, and when warm manifested signs of life, crawling back as in the spring. Dr. Shimer's observations upon this point are sufficiently interesting to quote:

After the early autumn frosts they left their feeding-grounds on foot in search of winter quarters; none could be seen on the wing as at harvest time. For a winter retreat they resorted to any convenient shelter they might chance to find, as long grass, weeds, boards, pieces of wood, rails, fallen tree leaves, etc.

In January, 1865, I next examined their condition; those that I found in the sheaths of the corn-leaves above the snow, and had been thus exposed during the previous severe weather, when for several successive days the thermometer was 15° to 20° below zero, were invariably found dead, without exception, and those beneath the snow were alive. This observation was made in the common farm corn-fields, as they might be found anywhere all over the wide country, for in autumn the Chinch-bugs remained in great numbers in the corn-husks and under the sheaths of the blades, as well as in other winter retreats. Upon various occasions, as the winter advanced, I brought in corn-husks filled with ice, inclosing the Chinch-bugs in the crystallized element; when the ice was thawed they were able to run, apparently unaffected by that degree of cold. It is therefore proved that these insects possess vitality sufficient to withstand the effect of a temperature below the freezing point, and perhaps below zero, as must have been their condition in these ice-bound husks; but when in the open air, exposed to the sweeping prairie winds, 15° to 20° below zero for a long time, they succumb to the cold.

March 7, 1865.—The snow having cleared off from the ground I examined the condition of a host of these Chinch-bugs that had chosen for their winter covering cord-wood sticks lying on the ground, entirely surrounded by frost and ice. Of these 20 per cent. were living; those that were more fortunate in their selection of winter quarters fared much better. From a single handful of leaves picked up at one grasp from beneath an apple tree I obtained 355 living and 312 dead Chinch-bugs; and of their lady-bird enemies that had entered the same winter quarters with them, 50 were living and 10 dead. Of these Chinch-bugs I placed a number in comfortable quarters in the house in a small pasteboard box—not in a stove room—together with some coleopterous insects casually gathered among the Chinch-bugs; after one month I found the latter all dead and the former living.

The entire month of March was rain, snow, thawing, freezing, alternately, seeming to be very uncomfortable for any living creature to remain out of doors with so poor a shelter and on top of the ground.

April 1–6.—I again made repeated examinations of these Chinch-bugs in their winter quarters, and found about the same proportion of them living as noted on the 7th of March. At this time they wandered away on foot from their winter quarters.

Mr. G. A. Waters, in the Farmer's Review for October 19, 1887, gives the following interesting observation bearing on the same point:

"In 1881–'82 I observed a bunch of fodder that had fallen into a ditch that the heavy rains had washed near by a shock. The fodder had been overflowed with water, which had stood over the fodder long enough for a sheet of ice to form over it, the water subsiding

in a few days and some thaw occurring, I pulled the stalks out of the mud to get the ears of corn off, and in husking the ears found quite a number of Chinch Bugs which had been immersed for a week or more. On exposing them to the warm sun they crawled around lively."

Where they are hibernating in numbers they can often be detected more readily by their strong "bed-buggy" odor than by sight, as was pointed out by Dr. Riley. Dr. Lintner, in October, 1883, found this method of searching for them "more convenient and infallible than looking for them."

Mr. Bruner calls our attention to the fact that the Osage and other brushy hedges in the West are great collectors of leaves and trash, blown there by the winds, and that they form exceptionally good hibernating places for the Chinch Bugs, which take advantage of them in great numbers. So great a nuisance are the hedges from this point of view that Mr. Bruner seriously advocates their gradual removal and the substitution of a less compact division between fields.

HABITS.

With the warm days of spring the hibernating individuals issue from their winter quarters and copulate. Dr. Shimer has described a love-flight which he noticed at this time. The date was May 16, 1865, and the atmosphere was swarming with Chinch Bugs on the wing. As shown by Walsh and Riley (Am. Ent., I, 173), it is probable that this occurrence was exceptional, and that the insects do not normally mate in this way; that the swarming flight was the result of a great abundance of the insects. The insect flies in spring and fall and also somewhat in late July and early August as the first brood becomes winged. In the fall they attain wings as the corn hardens and their flight is then the result of a starvation impulse. In July and August the flight of the fledged individuals of the first brood is not very common, except when they occur in exceptionally great numbers. During the past season Professor Osborn observed them coupling at Ames prior to July 25, while upon this date he observed them swarming in the air, flying past his window in immense numbers and with the wind (southeast to northwest). They were first noticed shortly after 1 p. m. July 27 they were again noticed on the wing, but not in such great numbers as before. They were flying with the wind from northwest to southeast. August 3 hosts of them were observed on the wing, while others were coupling on the ground. Others were observed coupling as late as August 16.

The majority of the hibernating individuals seem, from the evidence, to copulate in the spring and without flying, but according to Professor Riley many of them make love in the fall preparatory to seeking winter quarters, and Mr. James O. Alwood, of Columbus, Ohio, writes that he found them copulating in the field of uncut Pearl Millet at the Ohio Agricultural Experiment Station as late as October 27, 1887.

The eggs of the Chinch Bug, which we have already described, and which are figured on Plate I, Fig. 2, are laid in the spring for the first brood, and usually underground and upon the roots of plants infested. They are, however, often found above ground upon the withered sheaths near the bases of the grain stalks, or often upon the blades of the leaves. They are deposited in small clusters, like those shown upon the plate.

Professor Riley says: "A wheat plant pulled from an infested field in the spring of the year will generally reveal hundreds of these eggs attached to the roots, and at a somewhat later period the young larvæ will be found clustering on the same and looking like so many moving atoms." The eggs are not specially small, and when we consider the small size of the female which lays them (Dr. Shimer says that each female lays 500) this seems very large, until we reflect that they are not all deposited at once, and that after the laying of the first few others are probably developing in the ovaries, for the process of oviposition occupies from ten days to three weeks. It has long been known that the eggs were laid in the ground, and an accurate description was given by Professor Riley as early as 1866. The relative abundance of the eggs upon the stalk and upon the roots may be changed somewhat, as Dr. Thomas has pointed out, by the character of the soil. Where the soil is very damp the majority of the eggs are doubtless laid upon the stalks, whereas if the earth is dry and easily penetrated the great majority of them will be found upon the rootlets and upon the stalks beneath the ground.

According to Professor Riley the eggs hatch, on the average, in two weeks. The young larvæ begin to take nourishment as soon as possible after hatching. They insert their beaks sometimes even before they emerge from the earth, but more often crawl up the stalk, before beginning to pump. They grow with considerable rapidity, and swarm over the stalk upon which they were born, walking about with ease, and wandering from one stalk to another if occasion demands. As we have already shown, four molts are undergone before the insect reaches the perfect state, and generally from five to seven weeks elapse from the hatching to the final molt. Dr. Shimer's repeated observations show that at Mount Carroll, Ill., the imago usually appears in from fifty-seven to sixty days after the laying of the eggs and about forty-two days from the hatching of the larvæ. By the time the majority of the insects of this first generation are full grown, or even before, the wheat has become too hard to offer them much nourishment, or harvest time has arrived, and they begin to migrate in search of food. Neighboring cornfields offer a more tempting diet, and in seasons of great abundance they march in numerous colonies, moving by a common impulse from the wheat to the corn. Strange to say, although the commoner form possesses wings the insect does not generally take flight, but prefers to walk along the ground. Occasionally, however, at this time they take wings and scatter. This, however, is rarer when the insects are plentiful than when they are comparatively scarce. Under no circumstances will these insects take to flight to escape danger.

Dr. Shimer says: "No threatening danger, however imminent, whether of being driven over by grain-reapers, wagons, or of being trodden under foot, will prompt it to use its wings to escape. I have tried all imaginable ways to induce them to fly, as by threshing among them with bundles of rods of grass, by gathering them up and letting them fall from a height, etc., but they invariably refused entirely to use their wings in escaping from danger." The migration takes place often and, according to some authors, usually before the majority of the broods have attained full growth. There are always many immature individuals among a large host, and often the army is composed almost entirely of such. In fact, at these times there is apt to be a general confusion of so-called larvæ, pupæ, and adults, owing

to the fact that some hibernating females oviposit much in advance of others and to the other fact, previously mentioned, that a single female takes several days or even weeks to lay all of her eggs. Professor Forbes records egg-laying, presumably by hibernating individuals, from the last week in May (at Decatur) until the last week in June (at Warsaw), thus making certain individuals of the first brood one month later in development than others in two localities not far distant (140 miles) and of about the same latitude. There are many accounts in print which are almost incredible tales of the size of these migrating hordes, and yet they are probably only too true.

Dr. Thomas states that the migration upon foot seldom exceeds 80 rods, but the winged individuals fly to much greater distances. Instance was given in the Farmer's Review for August 17, 1887, where a little patch of sweet-corn grown in the midst of pine woods in northern Wisconsin, 8 miles from a cultivated crop of any kind, was badly infested with the Chinch Bug. This appearance of the bugs probably resulted from the flight thereto of mature individuals.

It naturally results from the wide difference in the method of growth of the crops that the Chinch Bugs, after migrating from wheat to corn, appear to be much more numerous upon the latter crop than they were upon the former, in spite of the great numbers usually killed in the act of migrating, for a single stalk of corn will be obliged to support the Chinch Bugs from a great many stalks of wheat. Moreover, the bugs swarm upon the first few rows and destroy them before invading the entire field generally. The outer rows, of course, under these circumstances are often black with bugs. The pupæ work their way down between the leaves and the stalk and there cast their skins and issue as adult insects. The leaf sheath is often thus filled with exuviæ. The eggs for the second brood are also often, if not usually, deposited in this same situation—behind the sheaths of the lower leaves—and on hatching the young bugs remain there feeding and growing and casting skins, sometimes even until the advent of cold weather and their consequent winter torpor. Others issue from these sheaths, particularly when they are especially abundant, or, failing to find satisfactory locations on the outer rows, take wings and fly to the center of the field and become generally scattered. They feed upon the Corn or Rye, as the case may be, and upon the surrounding grasses or in the fields of Millet or Hungarian grass until the approach of fall, by which time nearly all are once more full-grown. Mr. Webster observed them at La Fayette, Ind., in August, forcing themselves down into cut stubble of Foxtail Grass (*Setaria glauca*) for the purpose of undergoing the last molt. He counted upwards of twenty in a single stalk.

We may mention in this connection, as reported to us by Professor Osborn and also as published in the Country Gentleman for August 25, 1887, that President Chamberlain, of the Iowa Agricultural College, dug a single root of Hungarian grass at Ames, Iowa, the first week in August, upon which were counted 3,025 bugs. Earth was removed with the root to the depth of 3 inches (1 inch surface), in all about 4 cubic inches.

In the North the majority of them are ready to hibernate by the time the field corn is harvested. Farther South, however, the corn grows too hard for them a considerable time before the weather is cold enough to compel them to seek winter shelter. In North Carolina, as we have already shown, a third brood has appeared by the time the corn becomes hard and the bugs seek the Crab-grass and

there feed until ready for hibernation, finding in this grass, moreover, good shelter for the winter.

The general statements here given apply to the average Chinch-bug year in Illinois, Missouri, and the surrounding States, as the articles from which we have drawn our main facts are the results of observations made in these States. The life history and habits of the species undoubtedly differ considerably in the more southern States, where, however, it seldom does much damage. It is very doubtful, however, that the habits differ so greatly as to admit of the correctness of the statement quoted by Fitch from the Southern Planter (XV, 269) that the eggs are laid in the ground in autumn, where they remain through the winter and until the warmth of the ground the following year causes them to hatch! This great error (at least for the West and North) is unfortunately perpetuated by Dr. Lintner in his second report as State Entomologist of New York, p. 153.

There seems, in fact, every reason to suppose that this was simply a guess on the part of the editor of the Southern Planter, without the slightest observation to substantiate it. At our request Professor Atkinson examined a number of females found near Chapel Hill, N. C., in November, but found no evidence of mature eggs. He also searched carefully for deposited eggs with, of course, negative results. He states that Mr. Thomas S. Weaver, of Chapel Hill, has observed the bugs for the past ten years, and states that they never deposit in autumn.

In exceptional seasons and under exceptional conditions the life history and habits will vary considerably even in the localities referred to; for example, in 1882, according to Professor Forbes' first Illinois report, there was evidently in some parts of the State but one brood, and the first young bugs were not seen before July 10. The eggs of the *first* brood were in some localities this season laid upon corn.

NATURAL ENEMIES AND DISEASES.

INSECT ENEMIES.—No true internal insect parasites of the Chinch-bug have yet been found. In fact, very few of the smaller Heteroptera are parasitized except in the egg state. The minute Proctotrupidæ belonging to *Teleas* and *Telenomus* infest the eggs of allied species and may ultimately be found to attack the eggs of the Chinch Bug. Outside of these genera, however, we can hardly expect any aid from parasitic insects. In this connection, although it does not strictly come under this head, we may mention that in 1885 Mr. Webster found a species of Mermis ("hair snakes") among the dried moultings and dead bodies of certain Chinch Bugs in a stalk of Setaria, which gives rise to a strong probability that one of these creatures will be found to infest the bug. Many predaceous insects destroy them, although their disgusting odor is probably more or less a protection.

Mr. Walsh, in 1861, mentioned four Lady-birds, viz, the Spotted Lady-bird (*Hippodamia maculata*, Plate III, fig. 6), the Trim Lady-bird (*Coccinella munda*, now called *Cycloneda sanguinea*, Plate III, fig. 4), and two species of *Scymnus*. In 1882 Professor Forbes found five species of Lady-birds (including the first two mentioned by Walsh) extremely abundant on corn (15 or 20 to a hill) which was infested by hosts of Chinch Bugs. The contents of the stomachs of a few specimens of each were examined, with the following re-

sults: In three specimens of *Hippodamia maculata* no traces of Chinch Bugs were found, the food consisting of the spores of lichens, the pollen of Rag-weed, and traces of plant-lice. One-third of the food of *Hippodamia convergens* (Plate III, fig. 7), (5 specimens examined) consisted of equal parts of Chinch Bugs and plant-lice. In four specimens of *Hippodamia glacialis* 8 per cent. of the food was found to be Chinch Bugs, 18 per cent. plant-lice, and the rest vegetation. A single specimen of *Coccinella 9-notata* had eaten no insect food. Three specimens of *Cycloneda sanguinea* had eaten some plant-lice, but no Chinch Bugs. From these observations Professor Forbes concludes that it is possible that the Lady-birds were attracted "rather by the stores of fungi in the field than by the Chinch Bugs and plant-lice."

The Weeping Lace-winged Fly (*Chrysopa plorabunda*, Fitch, Plate III, fig. 11), described originally by Dr. Shimer as *Chr. Illinoiensis*, has been found by Dr. Shimer to destroy the Chinch Bug. Professor Riley records the fact that the Insidious Flower-bug (*Triphleps insidiosus*, Say, Plate III, fig. 12), an insect which is often found in company with the Chinch Bug and which has been mistaken for it in reality, feeds upon the pest. This is the insect which was sent to Dr. Fitch as a Chinch Bug and which he described as *Anthocoris pseudochinche* in his second report. Professor Riley also records the fact that he has observed the Many-banded Robber (*Milyas cinctus*, Fab. Plate III, fig. 8) in the act of preying upon the Chinch Bug, and Dr. Thomas considers this insect the most efficient of the insect enemies of the pest.

Two of Professor Riley's correspondents, in 1874, stated that ants destroyed the eggs of the Chinch Bugs, but the observation lacks scientific confirmation. Professor Forbes, in 1882, observed a small ant (*Lasius flavus*) in extraordinary numbers in fields of Broom-corn and Sorghum, and both he and a farmer, whom he does not mention by name, made each an independent observation upon an ant which was carrying off a Chinch Bug in its jaws, but repeated dissections of Ants found in such fields failed to show that they had fed on the bugs.

Professor Forbes, in his 1882 report, adds to the list of observed insect enemies a common Ground-beetle—*Agonoderus pallipes* (*comma*), Fabr. (Plate III, fig. 10) of which, upon dissection, one-fifth of the total food was found to be Chinch Bugs. This is the insect figured upon Plate I of Bulletin 12 of the Division of Entomology, and which is there stated to destroy seed-corn in the ground, so that its beneficial qualities are offset by its injurious tendencies.

The evidence of Dr. Shimer, Mr. Walsh, and others is quite sufficient to establish the fact that the Lady-bird and the Lace-winged Fly mentioned will feed upon the Chinch Bug, and Dr. Shimer's evidence in favor of the latter insect is particularly strong. His testimony as to the great abundance of the Lady-birds upon corn infested by Chinch Bugs is, of course, only presumptive evidence of their good work in destroying this insect. It is unquestionable, however, that the Lady-birds prefer plant-lice to the Chinch Bugs, and in at least one instance which has been reported to us, when the Lady-birds were present upon corn in considerable numbers and when this crop was infested by the Chinch Bug, a careful study by the observer (Mr. Lawrence Bruner) showed that the Corn Aphis was also present and that the Lady-birds were feeding upon these latter, and did not, so far as he could see, touch the Chinch Bugs. Professor

Forbes' stomach examinations, previously mentioned, also tend to cast discredit upon the Lady-birds as Chinch Bug destroyers.

VERTEBRATE ENEMIES.—Professor Riley published many years ago, in the Prairie Farmer, the fact that the common Quail or "Bob White" (*Colinus virginianus*) was a most efficient destroyer of the Chinch Bug, and this fact has since been confirmed by other writers.

Dr. Riley says: "In the winter time, when hard pushed for food, they must devour enormous numbers of the little pests, which winter in just such situations as are frequented by the quail; and this bird should be protected from the gun of the sportsman in every State where the Chinch Bug is known to run riot." We may add the corroborative evidence of Mr. Bruner, who as a taxidermist has had special opportunities for studying the habits of the quail.

"Protect the birds, and, above all, the quails; for they destroy countless numbers of hibernating insects of various kinds that are to be picked up about the hedges and such like resorts frequented by these birds throughout the winter. Although belonging to the gramnivorous birds, the quail is essentially insectivorous, except in inclement weather, when the latter are not easily to be obtained. In my profession as taxidermist I have dissected many different species of birds, in the crops of which were contained injurious insects of various kinds, the Chinch Bug among others. In no other instance do I remember of the presence of this insect in the crop of a bird in so great numbers as in that of the Quail. As a rule but few birds, mammals, reptiles, or rapacious insects seem to relish any of the odoriferous members of the Hemiptera or true bugs. In winter, however, this repugnance is partially overcome, and now and then even a Chinch Bug seems a delicate morsel when 'meat' is scarce."

The Prairie Chicken, the Red-winged Blackbird, and other birds have been reported as feeding upon the Chinch Bug, and Professor Forbes mentions the fact that one Cat-bird, three Brown Thrushes, and one Meadow-lark were found in 1880 to have eaten these insects "in barely sufficient number to show that the birds have no unconquerable prejudice against them. A single house-wren, shot in 1882, had also eaten a few Chinch Bugs." Dr. Thomas states that the common Frog, according to Professor Ross and others, consumes a large number of the bugs. "Professor Ross goes so far as to express the belief that the destruction of these animals by draining their natural haunts is one reason why the Chinch Bug is enabled to multiply as it does in some seasons."

No account of an injurious insect is complete without an enumeration of its natural enemies, and hence this summary has been given. It is plain, however, that the foes of the Chinch Bug are neither so numerous nor so active in its pursuit as are those of most of our other injurious insects. Almost the solitary exception seems, from the evidence, to be the common Quail, and on this account the following short table has been compiled. It illustrates the months in which the shooting of quails is allowed in the States in which the Chinch Bug becomes or may become injurious, and it shows that while these birds are in the main tolerably well protected, certain of the States which suffer most from the Chinch Bug might with profit follow the example of Colorado or Dakota and protect the Quail altogether for a series of years.

New York: Shooting of quails allowed from November 1 to January 1.

Maryland: Shooting of quails allowed from November 1 to December 24. There are, however, in this State, local county laws, some of which allow the shooting as early as October 1.

Virginia: Shooting of quails allowed west of the Blue Ridge October 15 to January 1, except in Rockbridge County, where it is allowed from October 15 to January 15; elsewhere October 15 to January 15.

Texas: Shooting of quails allowed from October 1 to April 1.

Georgia: Shooting of quails allowed from October 15 to April 1.

Wisconsin: Shooting of quails allowed from September 1 to December 1. Trapping prohibited.

Michigan: Shooting of quails allowed from November 1 to January 1. No trapping or snaring allowed for market.

Pennsylvania: Shooting of quails allowed from October 15 to January 1.

Tennessee: Shooting of quails allowed from October 1 to April 1 in Rutherford, Shelby, Tipton, and Fayette Counties; September 1 to February 1 in Robertson, Davidson, Lincoln, and Maury Counties; September 15 to March 1 in Montgomery and Cheatham Counties.

Missouri: Shooting of quails allowed from October 15 to February 1. Trapping prohibited except by owner of premises.

Delaware: Shooting of quails allowed from November 15 to January 1.

North Carolina: Shooting of quails allowed from October 15 to April 1, except in counties of Clay, Cherokee, Graham, Henderson, Jackson, Macon, Transylvania, Tyrrell, Johnston, Jones, Ware, Onslow, Carteret, and Columbus, in which they are not protected; in Currituck County, December 1 to April 1.

Iowa: Shooting of quails allowed from October 1 to January 1; no more than twenty-five quails to be killed in any one day by any one person.

Dakota: Quails protected absolutely to 1890.

Illinois: Shooting of quails allowed from November 1 to January 1. Snaring and trapping forbidden.

Ohio: Shooting of quails allowed from November 10 to January 1. Snaring and trapping forbidden. In Fulton County quails protected to November 1, 1890.

Nebraska: Shooting of quails allowed from October 1 to January 1. Snaring and trapping forbidden.

Indiana: Shooting of quails allowed from October 15 to December 20.

Minnesota: Shooting of quails allowed from September 1 to December 1. Trapping prohibited.

District of Columbia: Shooting of quails allowed from November 1 to February 1. Trapping prohibited.

South Carolina: Shooting of quails allowed from October 1 to March 15.

Montana: Shooting of quails allowed from August 15 to November 15.

Arkansas: Shooting of quails allowed from October 1 to March 1.

Colorado: Quails protected at all times.

West Virginia: Shooting of quails allowed from October 15 to January 1. Snaring prohibited.

Kentucky: Shooting of quails allowed from October 15 to February 1.

Idaho: Quails protected until September 1, 1887. (Present status of law unkown.)

New Mexico: Shooting of quails allowed from September 1 to May 1.

Kansas: Shooting of quails allowed from November 1 to January 1.

This compilation is drawn up in the main from an extended abstract of the State game laws, published in the American Field for August 20, 1887, Vol. XXVIII, No. 8.

DISEASES.—The Chinch Bug has long been known to be subject to a so-called bacterial disease, which occasionally kills it off. Dr. Shimer, in his long article in the Proceedings of the Academy of Natural Sciences of Philadelphia, gives the following account of his observations upon this disease in 1865 (Proceedings of the Academy of Natural Sciences of Philadelphia for 1867):

July 16.—A farmer 4 miles from here informed me that a black coleopterous insect was destroying the Chinch-bugs on his farm very rapidly; and although I found his supposition to be an error, yet I found many dying on the low creek-bottom land from the effects of some disease, while they are yet in the larvæ state—a remarkable and rare phenomenon for insects thus in such a wholesale manner to be dying without attaining their maturity—and no insect enemy or other efficient cause to be observed capable of producing this important result.

* * * * * * *

On the low ground the young Chinch-bugs are all dead from the disease above alluded to, and the same disease is spreading rapidly on the hills and high prairies.

"The weather has been very wet since the 1st of July, and the barley above alluded to, which I plowed beneath the ground, did not die, but assumed a yellow, sickly appearance; in its shady, compressed, unnatural position, the ends of the heads project from beneath the furrows. The Chinch-bugs also remained alive for a time, but feeding on the sickly grain and shaded from the sunlight, what little we had were attacked by disease in the same manner and about the same time as those on the low creek-bottom lands, meeting very rapidly the same fate, so that very few of them ever found their way to the neighboring corn.

July 28.—In the fields where sixty days ago I saw plenty of eggs, and forty-two days ago an abundance of young Chinch-bugs, the imago are beginning to develop quite plentifully. Great numbers in all stages of their development are dying of the prevailing disease.

August 8.—The majority of the Chinch-bugs yet alive are in the imago state, but they are being rapidly destroyed by the prevailing epidemic disease—more fatal to them than the plague of Asiatic cholera ever was to man; more fatal than any recorded disease among men or animals since time began. Scarcely one in a thousand of the vast hosts of young bugs observed at the middle of June yet remain alive, but plenty of dead ones may be seen everywhere, lying on the ground, covered with the common mold of decomposing animal matter and nothing else, even when examined by the microscope. Even of those that migrated to corn-fields a few weeks ago in such numbers as to cover the lower half of the corn-stalks, very few are to be found remaining alive; but the ground around the base of the corn-stalks every few days is to be found literally covered with their moldering, decomposing dead bodies. This is a matter so common as to be observed and often spoken of by farmers. They are dead everywhere; not lying on the ground alone, but sticking to the blades and stalks of corn in great numbers, in all stages of their development—larva, pupa, and imago

August 22.—It is almost impossible to find even a few cabinet specimens of Chinch-bugs alive, so that I am quite sorry that I did not secure a large supply of specimens while they were so numerous in former years; for it really appears quite probable that even cabinet specimens will be hard to secure, whereby to remember the fallen race of the unnumbered millions of former years.

September 13.—After a whole day's searching in the corn-fields I have just been able to find two larvæ and a few imago Chinch-bugs, against the great numbers above alluded to in the corn about this time last year.

* * * * *

It is generally believed among entomologists that insect enemies are the most efficient means in nature for exterminating noxious insects; but in this remarkable fact in the history of insects the great epidemic of 1865 (there can be no doubt about this being an epidemic disease, because the insects died without attaining their maturity) we find a greater enemy, the greatest insect enemy ever recorded, a dreadful "plague," that in a few days almost utterly annihilated a race of beings living in the northern part of the valley of the Mississippi, outnumbering all the human beings that have ever lived on this planet since the morning of creation.

This disease among the Chinch-bugs was associated with the long-continued wet, cloudy, cold weather that prevailed during a greater portion of the period of their development, and doubtless was in a measure produced by deficient light, heat, and electricity, combined with excessive humidity of the atmosphere, whereby an imperfect physical ("bug") organization was developed. The disease was at its maximum during the moist weather that followed the cold rains of June and the first part of July. The young Chinch-bug spent a great portion of its time on or near the ground, where its body was colder than the atmosphere, hence upon philosophical principles there must have been an excessive precipitation of watery vapor in the bronchial tubes. These are the facts in the case, but in the midst of the great obscurity that envelops epidemic diseases among men, it would be only idle speculation to attempt to define the cause more definitely than the physiological laws already observed seem to indicate. At all events it will require many years of warm, dry summers, and accompanying winters of plenty of snow for protection, to re-instate the lost innumerable armies of this insect.

During the summer of 1866 the Chinch-bugs were very scarce in all the early spring, and up to near the harvest I was not able, with the most diligent search, to find one. At harvest I did succeed in finding a few in some localities.

Professor Forbes took up the study of the Chinch-bug disease in August, 1882, and has published several interesting accounts of his results. A short summary was published in his first report as State

Entomologist of Illinois for the year 1882 of the long account of his studies and experiments, and it is in such shape that we reproduce it here:

On the other hand, a much more important rôle is apparently played by certain obscure parasites not previously detected. One of these is a minute bacterium (*Micrococcus insectorum*, Burrill) infesting the alimentary canal, closely allied to the *Micrococcus* found in the stomach and intestines of Silk-worms, and now known to cause some of the destructive diseases of that insect. From the fact that these parasites were extremely abundant in specimens from a field where the bugs were rapidly dying, while in those from adjacent fields there were relatively very few, it was considered probable that they were related to this destruction of the bugs. This conclusion was supported by the fact that they were more abundant in old bugs than in young, while the mortality referred to evidently also chiefly affected the older individuals. It was found easy to cultivate the bacterium artificially in organic infusions, but no opportunity offered to apply it to healthy insects. Until this experiment is made and the effects carefully studied, it must remain possible that the coincidence noted was merely accidental and of no particular significance.

Another parasite discovered is similar to that well known as a common enemy of the house-fly, and belongs to the same genus (*Entomophthora.*) This attacks both old and young Chinch-bugs, and finally imbeds their bodies in a mass of mold. There is some reason to believe that this was the active agent in an immense destruction of Chinch-bugs which occurred in Northern Illinois in 1866, as described by Dr. Shimer, of Mount Carroll. Evidence is adduced of the possibility of artificially cultivating this parasite also, and applying it to the destruction of insects.

Since the publication of this report Professor Forbes has taken up the study of bacterial diseases of certain other insects, but there has been, so far as we are aware, no practical outcome as yet. The subject, however, has a rather hopeful look, although we should be inclined to expect more from the *Micrococcus* than from the *Entomophthora.* The evidence mentioned as to the possibility of artificially cultivating the latter is chiefly a translation of a paper by Metschnikoff in the Zoölogischer Anzeiger for 1880, pp. 44-47, in which it is shown that the Russian naturalist successfully induced the growth of the fungus, *Isaria destructor*, which had destroyed the celebrated *Anisoplia austriaca*, a grain pest in Russia, in beer mash. Successful attempts were made to infest healthy larvæ with green spores taken from diseased larvæ found in the fields, but no mention is made of success or even of experiment with the only practical substance, the beer-mash culture.

Professor Riley has always doubted the possibility of any practical success in this direction, and has pointed out the difficulties in the way. (See American Naturalist, November, 1883, p. 1170.)

In the introduction of the Fourth Report of the U. S. Entomological Commission (LXXXV) he makes use of the following language:

In treating of the use of yeast ferment or other fungus germs we have used essentially the language of the first edition. Time has only served to confirm us in our opinion of their practical futility in the field. The question of the practical use of these micro-organisms—these disease germs—as insecticides is a very fascinating one, and is much written about just now; but unfortunately it proves most alluring to those who have had the least practical experience in coping with injurious insects in the field, and is much more apt to assume importance to the closet theorists than to those who, from experience, are conscious of the difficulties involved in its applicability.

It will be appropos to quote Professor Forbes' latest utterance upon this point. He says:

Finally, *the artificial cultivation of the germs of the contagious diseases* of the chinch bug, with a view to spreading these diseases at will by means of such artificial culture. This is a theoretical remedy only, and much additional study and experiment will be required to put it on a practical basis.

WET WEATHER AND THE CHINCH BUG.

The great preponderance of evidence favors the idea, now considered well established, that wet weather is inimical to this insect. Dozens, we may almost say hundreds, of instances are on record in which the Chinch Bugs, after successfully hibernating in great numbers, have been rendered harmless by a wet spring, and in which, having laid their eggs and appeared again as the spring brood with greatly increased forces, a spell of rainy weather in early summer has caused them to vanish. Hence it follows that dry seasons favor the increase of the pest, and careful observation convinced Riley and others that after a season of moderate abundance (presumably, therefore, not a wet season) the occurrence of the bugs in destructive numbers the next season depends almost entirely upon the wetness or dryness of the ensuing spring.

The exact method in which wet weather accomplishes the destruction of the insect is a somewhat disputed point. That it is not actual submergence was pointed out by Professor Riley in his Second Missouri Report, and still further proven by an observation made by Hon. William McAdams and reported by Professor Forbes in his first report as Entomologist of Illinois, and which is sufficiently interesting to quote: "In his vicinity, in Jersey County [Ill.], they [the Chinch-bugs] were extremely abundant in the grain early in the spring, but were all apparently swept out of the country by a long and violent storm. Some days afterwards, when the water had subsided, he noticed in pulling over the drift-wood in the river bottoms immense numbers of Chinch-bugs among the rubbish, most of them still alive and crawling about."

Professor Forbes also concludes that simple exposure to moisture hardly has the effect attributed to rain, from experiments which he made as follows: "A number of hills infested by the bugs were successfully transplanted to boxes and variously treated with water for ten days. Some selected examples were thoroughly drenched every day, both ground and stalks; in other boxes only the ground was watered; in still others the corn was sprinkled every day, but the ground protected, and the remainder were left with only sufficient attention to keep the corn alive. During the time for which these experiments were continued no appreciable effect whatever was produced upon the bugs infesting the stalks. Those where the corn was watered were washed down upon the ground each time, but soon dried off and climbed up the stalk. At the end of this time the bugs under observation all commenced to disappear indiscriminately, without reference to the mode in which the corn had been treated, and the experiment was thus abruptly closed. Enough was learned, however, to show that a succession of heavy daily showers for more than a week would have no appreciable effect upon these insects in that stage. The weather was warm and pleasant, and the condition under which the experiments were carried on made it impossible to saturate the air."

So general a conclusion, it seems to us, is hardly warrantable from the conditions under which the experiments were made. If "the weather was warm and pleasant, and the condition under which the experiments were carried on made it impossible to saturate the air," the effect could hardly help but differ from that of a heavy shower in a corn-field, particularly from that of "a succession of heavy daily

showers for more than a week," when there would be considerable cloudy weather and the atmosphere on the whole would be moist.

Professor Riley has mentioned the fact that the larvæ and pupæ are more readily killed by the wet weather than the adult insects, but that the latter are also killed.

Mr. Walsh (Am. Ent., I, 175, 1869) gives the emphasis of italics to the following sentence: "In a hot, dry season Chinch-bugs are always the worst; in a wet season it is impossible for them to do any considerable amount of damage." Dr. Shimer (*loc. cit.*) in his account of the epidemic argued that it was doubtless the indirect effect of the wet weather. Dr. Thomas (Bull. 5, U. S. E. C.) expressed the opinion that the wet weather gave rise to a minute fungus which is the direct cause of the death of the insect.

Professor Forbes says: "The phenomena connected with the action of parasites which I have above described were apparently independent of any appreciable general cause, as they were most manifest at a time when the weather had been warm, dry, and altogether unexceptionable for from one to two months. It is not unlikely, however, that wet weather may have the effect to stimulate the development of this parasite, either directly or indirectly—a hypothesis which will reconcile all the facts now known, as well as the conflicting explanations of them which have been hitherto put forth."

Assuming the dry weather abundance and wet weather scarcity of the Chinch Bug to be proven, Dr. Thomas in 1880 published an elaborate article in which, by a comparison of the rain-fall for forty years with the destructive appearance of the insect for the same period, he not only established a definite relation between them, but upon an admittedly somewhat uncertain septenary periodicity of rainfall advanced the following practical conclusions:

The first and very important practical fact revealed is that we may expect at most but two Chinch-bug years in every seven, with the strong probability, amounting almost to a certainty, that there will not be two in succession. As heretofore stated, two successive dry years are necessary in order to develop this species in excessive numbers; the rain-fall records seldom show three dry years in succession, hence the Chinch-bugs are not likely to appear in injurious numbers in two successive years. The years 1854 and 1855 may, perhaps, form an exception to this rule. It is possible that the second brood of the first year may be sufficient to excite alarm, but experience has shown that they do but little injury. We may, perhaps, with safety assume as a general rule, subject to occasional exceptions, that they will not appear more than once in excessive numbers during any of the septenary periods.

If the facts shown in reference to periodicity in our rain-fall are confirmed by future investigations, and this periodicity shown to be a meteorological law of the area indicated, the practical advantage of this knowledge to our farmers is apparent to every one. By this knowledge they will be enabled to predict with a reasonable degree of certainty when to expect these insects, and can rotate their crops so as to suffer the least possible injury. This knowledge will also enable them to dispense with precautionary measures, except in such years as are likely to be followed by the appearance of the bugs.

Experience has shown, and farmers are now becoming fully aware of the fact, that spring wheat and corn are the crops that chiefly aid in sustaining and developing this pest. Why corn should aid in this respect is easily seen, as it is the only extensive crop on which the second brood can feed. But why spring wheat should aid more in developing them than winter wheat is not so easily explained, but that such is the fact must be admitted. It may possibly be accounted for on the presumption that the climate of the spring-wheat region is more congenial to them than that of the winter-wheat area.

These facts, combined with a knowledge of the time when the dry seasons are to be expected, will enable the farmers to substitute other crops as far as possible in place of spring wheat and corn. Even if the conclusion in reference to periodicity in rain-fall should prove erroneous, the fact that two successive dry years are necessary to develop this species in excessive numbers will suffice to give notice at least

one season in advance and allow the farmers to adapt their crops to the circumstances. When a dry season comes, and an examination shows that the bugs are on the increase, winter wheat, wherever it is possible to do so, should be substituted for spring wheat, and oats, as far as possible, for corn.

The uncertainty in reference to temperature will, perhaps, always prevent us from predicting with certainty that a coming year will be marked by the appearance of these insects, but we may say with assurance that a wet year will not be followed by a Chinch-bug year. Although this is not all we desire to know in this respect, it is nevertheless a very important fact and may be used to manifest advantage by our agriculturists.

It is proper to remark at this point that we have been speaking only of the rain-fall over the whole area designated and the general appearance of the Chinch-bug over the same area.

That these insects have appeared even in injurious numbers in limited localities in intermediate years, or times different from those indicated as possible Chinch-bug years, is certainly true. But if the theory advanced is correct when applied to the area designated as a whole, it will probably prove true when applied to more limited localities. That is to say, if the meteorological record of a given locality within this area for a long series of years is examined, it will probably reveal the fact that there is a similar periodicity in the rain-fall, though possibly not septenary. If this is found to be true, then the farmers of that locality will have a guide by which to rotate their crops and to take precautionary measures.

It therefore becomes important for each section to keep a record, at least of the rain-fall; for this will be of advantage, not only in counteracting the Chinch-bugs but numerous other species, and if the periodicity is ascertained, will enable the farmers to adapt their crops as far as possible to the wet or dry seasons.

In the October (1880) number of the American Entomologist (Vol. III), Dr. Thomas published practically the same article as that above quoted and stated that the bugs would probably appear over the region indicated in 1881. He advised in consequence the sowing of large areas of oats in 1881. Professor Riley, in his Annual Report for 1881–'82, page 87, mentioned this prediction and advice and showed that the prediction was fulfilled in part at least by the occurrence of the bugs in destructive numbers in several Western States. With regard to the adoption of Dr. Thomas' advice, however, he pointed out the rather curious fact that Dr. Thomas' own State (Illinois) was the only one of the large oat-producing States in which the acreage of this crop was not increased, but was somewhat diminished. Dr. Thomas, in the letter of transmittal to his report for 1881, announced the fulfillment of his prediction and predicted immunity for 1882. Professor Riley (*loc. cit.*) showed that in spite of frequent rains in the spring of 1882, and in spite of the fact that 1881 was a Chinch-bug year, the bugs appeared in great numbers in parts of Illinois, Kansas, and Missouri in April and May, but that by June the reports were less alarming. The year as a whole was not marked by any extensive damage.

Upon Dr. Thomas' theory the year 1888 should not be a Chinch-bug year, and, while not desiring to encroach upon his prerogative as a seer, we are inclined to hold the same opinion concerning this season at least.

Curiously enough, an anonymous writer (J. C. H. S., of Sedgwick County, Kans.) in the Prairie Farmer for June 10, 1882, commenting upon and criticising Dr. Thomas' theory, himself predicts that 1887 would be a year of drought and consequently a Chinch-bug year, a much more daring prediction than Dr. Thomas cared to make and which has yet been perfectly fulfilled. According to this writer's somewhat arbitrary system 1894 should again bring a severe drought.

We introduce here, as bearing upon the rain-fall influence in the interesting North Carolina locality, the following table of temperature and rain-fall at Chapel Hill, compiled by Professor Atkinson.

It will be noticed that while the total rain-fall in both 1886 and 1887 was greater than in 1885, that during September, October, and November, 1886, and March and April, 1887, was comparatively slight, and that during June and July, 1887, high temperature occurred with the comparatively heavy rain-fall.

Table of temperature and rain-fall for spring, summer, and autumn, at Chapel Hill, N. C., for the years 1885, 1886. *and* 1887.

[The temperature is expressed in degrees Fahrenheit.]	March.	April.	May.	June.	July.	August.	September.	October.	November.	Totals to October.
1885.										
Highest temperature	75	94	96	94	100	94	92	81	71	......
Lowest temperature	15	31	40	63	61	57	46	35	27	......
Mean temperature	49.3	55.3	66.5	74.7	77.3	74.8	68	56.6	52.3	......
Rain-fall (inches)	3.5	2.71	4.34	1.32	3.95	1.98	6.45	6.27	3.81	24.25
1886.										
Highest temperature	80	93	93	93	98.5	96	94	89	77	......
Lowest temperature	24	33	46	53	62	55	52	35	24	......
Mean temperature	49.3	59.6	67.7	78.8	76.9	75.9	75.9	58.6	49.1	......
Rain-fall (inches)	4.97	5.99	4	6.22	7.48	9.91	2.86	1.47	2.79	41.43
1887.										
Highest temperature	83	91	93	101.8	103	92	98	......	......	......
Lowest temperature	26	28	45	49.7	65.7	52	36	......	......	......
Mean temperature	46.9	58.3	70.6	74.7	79.8	74.4	69	......	......	......
Rain-fall (inches)	3.93	2.56	6.59	6.22	6.11	10.8	1.39	......	......	37.60

The following tables are published for comparative purposes. They are kindly furnished by the Chief Signal Officer, and include the official records of precipitation in Chinch Bug States for 1885, 1886, 1887:

Stations.	1885.	1886.	1887.
	Inches.	*Inches.*	*Inches.*
Maryland:			
Baltimore	46.04	52.11	43.59
Virginia:			
Cape Henry	36.55	[1]44.76	....
Chincoteague	41.85	45.23	[2]19.74
Lynchburgh	46.35	51.85	40.62
Norfolk	43.25	54.33	47.72
North Carolina:			
Charlotte	58.35	64.60	51.26
Hatteras	68.02	54.72	55.07
Kitty Hawk	54.78	[1]53.98	....
Macon, Fort	62.34	[1]47.50	....
Smithville (now Southport)	48.07	38.93	59.49
Wilmington	60.42	56.43	51.47
Indiana:			
Greencastle	50.11	[3]31.65	....
Indianapolis	39.51	39.88	33.08
Ohio:			
Cincinnati	33.94	31.35	35.08
Cleveland	39.93	37.34	35.36
Columbus	42.25	42.39	30.25
Sandusky	34.23	31.00	29.85
Toledo	33.19	32.90	32.01

[1]Closed December 31, 1886.
[2]Closed June 18, 1887.
[3]Closed November 4, 1886.

Stations.	1885.	1886.	Part 1887.
	Inches.	*Inches.*	*Inches.*
Illinois:			
Cairo	31.99	37.98	26.75
Chicago	44.37	26.77	29.13
Springfield	38.61	31.69	25.15
Wisconsin:			
La Crosse	30.70	22.49	17.37
Milwaukee	32.58	31.46	30.46
Minnesota:			
Duluth	19.96	33.37	28.56
Moorehead	22.68	26.76	21.97
Saint Paul	25.33	22.89	25.85
Saint Vincent	16.58	15.04	18.47
Missouri:			
Lamar	[1]47.05	33.48	35.72
Saint Louis	45.59	44.34	35.30
Kansas:			
Concordia	[2]17.11	28.24	25.26
Dodge City	23.71	19.35	15.80
Leavenworth	43.64	22.25	37.05

[1] Ten months' record.

[2] Eight months' record.

REMEDIES AND PREVENTIVES.

The remedies and preventives recommended as late as the publication of Professor Riley's Seventh Rept. Ins. Mo., and there considered by him, are as follows: Irrigation, burning, trapping, trampling, rolling, manuring, early sowing, mixing seed or protecting one plant by another, preventing the migration from one field to another by upright boards or by plowed furrows or ditches, abstaining from cultivation of grains upon which the insect feeds. These remedies were also treated in detail by Dr. Thomas in Bulletin 5 of the Commission. Since this although many changes have been rung in the agricultural newspapers on these remedies, very few entirely new ideas have been advanced. We may mention more particularly, before taking up a more detailed consideration of this question, the successful adoption of the kerosene emulsion for application at the time of migration or immediately afterwards.

PREVENTIONS.—*Clean Cultivation.*—With no insect more than the Chinch Bug is there greater necessity for clean cultivation. We have shown already that the insect hibernates under rubbish of all kinds, and that the grass and weeds growing in the fence corners and the leaves which accumulate there are admirable places for these insects to collect and winter. Where corn-stalks are left in the fields, and where rubbish of any kind is allowed to accumulate, there the bugs will surely be found. Therefore the more thoroughly a field is cleaned up in the fall, the more carefully the fence corners are weeded out, and the more the bare soil is turned under, the fewer will be the chances for successful hibernation.

Diversified Farming.—It follows from what we have said concerning food-plants of this insect and the crops most attacked that, from the Chinch-bug standpoint alone, to say nothing of its other advantages, the more diversified the system of crops the better chance there will be for preventing it. A farmer who plants only Winter Wheat, Corn, and small vegetable patches, as is the practice in so many parts of the West, will always be liable to lose a large share, if not all, of his expected remuneration from the attacks of this insect. "Diversified farming with wheat mainly left out" is the editorial recommendation of the Prairie Farmer (September 17, 1887), and is certainly an exemplification of condensed wisdom.

The object of the omission of Wheat, particularly Winter Wheat, is of course to afford as little food as possible for the first generation. Similarly the plan has been suggested of abstaining from Corn in wheat and other small grain-growing regions, with the purpose of affording as little food as possible for the *second* brood. The result of this plan will be that after harvest the bugs will make their way to the wild grasses, will disperse more, and vastly fewer will successfully hibernate than if there were the usual superabundant supply of food for the second generation.

Rotation of Crops.—From these same facts it also follows, with self-evident clearness, that crops attractive to these insects should not be sown year after year upon the same ground. This idea is so plain as to require no elaboration. Abstaining from the cultivation of grain upon which the insect feeds where, in spite of the efforts for protection elsewhere mentioned, the Chinch-bug damage is still great, will of course end the difficulty. Wheat, Barley, Rye, Hungarian grass, and Millet are all important crops, but there are others, such as Buckwheat, Clover, Flax, Hemp, all vegetables, and fruits which could well be made to take their place for a year or two or more if it should become necessary. The one great result of the Chinch-bug convention held in Kansas in 1881 was the adoption of a resolution to abstain from the cultivation of Wheat from the growing crops, the length of time not being mentioned. As we have previously shown, large areas of oats could be successfully grown, but in corn-growing regions most small grains must be left alone, and, above all, Winter Wheat and Barley. Even without concert of action among the farmers of a certain region, it will benefit the individual to abstain from wheat and to grow oats in preference in a year when bugs are expected; but concert of action is far preferable.

Early Sowing and Manuring.—From the evident fact that a strong, healthy, well-grown plant will better resist the attacks of the insect the deduction follows that Winter Wheat sown early, upon well-manured ground and given careful cultivation will be farther advanced in the spring and will suffer less from the attacks of the bug. Heavy manuring will also cause a denser growth, which experience shows to be prejudicial to the bugs.

Rolling.—The female Chinch Bug in the spring seeks preferably friable ground in which to lay her eggs, consequently rolling the land in the fall after the crop of winter wheat is put in will render it less favorable to such egg-laying. The same thing may be done with even better success after sowing Spring Wheat.

Sowing an unattractive Crop with Wheat.—Good results have been obtained, as shown by Professor Riley, by sowing one or two quarts of Flax to the acre in the spring among Fall Wheat. It is put in in early spring with a light harrowing and rolling. Its growth does not materially injure the crop. Flax and Barley have also been sown mixed upon the same ground, the seed being separated in cleaning. Similarly corn-fields which promised a poor stand have been harrowed and sown to Buckwheat. We have already mentioned in our section on food-plants the successful experiment detailed by Professor Forbes in sowing Timothy in the fall with Winter Wheat or Rye, and the same author states that in southern Illinois the sowing of Clover in spring on Winter Wheat is largely practiced, "with unquestionably good effect, provided that the clover grows freely enough to shade the ground by the time the young Chinch-bug gets fairly under way." In

that latitude, however, he states that the Clover often makes too slow a start to effect this purpose. Professor Riley also states that it is recommended to sow one bushel of Winter Rye with each twelve bushels of Spring Wheat, either for the same reason or from the idea that the bugs will prefer the younger to the older grain.

DIRECT WINTER REMEDIES.—Stress should be laid upon the great necessity for concerted work in winter time.

Burning.—Professor Riley says: "I can not lay too much stress on the importance of winter work in burning corn-stalks, old boards, and all kinds of grass, weeds, rubbish, and litter around grain-fields, and even the leaves in the adjoining woods, in and under all of which the little pest hibernates."

In almost every locality the insects will be found to have some particularly favored hibernating place, where they can be attacked and burned out. The locality studied by Professor Atkinson in North Carolina and mentioned in a previous paragraph is a particularly good instance. There a little careful search in the fall showed the bugs preparing to hibernate in great numbers in the Crab-grass, and nothing could be easier in the winter than to burn down every spear of this grass in the vicinity of the grain-fields. In the newer parts of the West, where unbroken prairie land adjoins fields of grain it is advisable to burn over the former early every spring. Indeed, this course is an absolute necessity under such conditions.

Fall Plowing and Harrowing.—After burning, if the soil can be plowed and harrowed, the chances for successful hibernation of the bugs which escape burning will be reduced to a minimum. In the same way, without burning, late fall plowing and harrowing will do much good.

Gas Lime.—Where gas lime can be easily and cheaply obtained, an application of 200 bushels to the acre will prove valuable as a fertilizer, and will destroy such hibernating insects as it may reach.

Trapping.—We quote again from Professor Riley: "Much good winter work may be done also in the way of trapping the bugs. In seeking winter quarters they show a decided partiality for any flat substance, such as old boards that do not rest too closely upon the ground. If all old boards that can be obtained are laid around the field in the fall in such manner that the larger part of the lower surface will not quite rest on the ground, which of course it will not do if the ground is in the least uneven or covered with grass, the bugs will collect under such traps, and during the cold weather of winter may be scraped from them onto dry straw and burned." He has also suggested that shocks of the corn-stalks should be made at intervals throughout the field before winter sets in, so as to attract the bugs which will congregate in the shocks, where they can be burned at leisure. Almost any inflammable rubbish could be used for this purpose. In the neighborhood of sorghum-mills bagasse has been used with good effect. The piles should not be too large or too compact. They should be placed during September and should be burned in December.

Trampling.—The following passage is from Professor Riley: "Where the custom of allowing cattle to range during the winter in the husked corn-fields prevails, even the few Chinch Bugs which secrete in the stalks are apt to get killed by the feeding and trampling."

DIRECT SUMMER REMEDIES BEFORE MIGRATION.—As is the case with so many other destructive insects, it is not until they are under full headway and in the act of doing their greatest damage that an

appeal is made to the entomologist for relief, and at such times it is usually by far the most difficult thing to give any advice. A wheat-field full of Chinch Bugs is as disagreeable a sight to the economic entomologist as it is to the farmer who owns it, for nothing can be done to save it. If the hand of Providence should interpose with a long-continued drenching rain, relief would be gained, but in almost no other way can the crops be saved.

Irrigation.—It was the fact just mentioned which led Professor Riley, in his Seventh Rept. Ins. Mo., to strongly recommend irrigation where it can be practiced. He says: "Irrigation, where it can be applied—and it can be in much of the territory in the vicinity of the Rocky Mountains, where the insect commits sad havoc, and with a little effort in many regions in the heart of the Mississippi Valley—is the only really available, practicable remedy after the bugs have commenced multiplying in the spring. I wish to lay particular stress on this matter of irrigation, believing as I do, that it is an effectual antidote against this pest, and that by overflowing a grain-field for a couple of days, or by saturating the ground for as many more in the month of May, we may effectually prevent its subsequent injuries. * * * We can not, at the critical moment, expect much aid from its natural enemies, for these are few, and attack it mostly in the winter time. We must, therefore, in our warfare with this pest, depend mainly on preventive measures where irrigation is impossible."

Later (Amer. Agriculturist, Dec., 1881, also Ann. Rept. as Entomologist, Dept. Agr., for 1881–'82, pp. 88, 89) he expressed himself even more explicitly upon this subject:

"I have found no occasion to change my opinion as to the value and potency of irrigation as a remedy for Chinch-bug injuries, a remedy, too, that is within the reach of most farmers; for there are few who might not, with the aid of proper windmills, obtain the water requisite for irrigating their fields at the needed time, while many have natural irrigating facilities. I have repeatedly laid stress in my writings on the importance of irrigation in combatting several of our worst insect enemies, and, aside from its benefits in this direction, every recurrence of a droughty year, such as the present, in large portions of the United States, convinces me of its importance as a means of guarding against failure of crops from excessive drought. I am glad to know that many farmers, and especially small fruit-growers in the vicinity of New York, are preparing in one way or another for irrigation whenever it becomes necessary, and I was pleased to hear Dr. Hexamer, at the late meeting of the American Pomological Society, urge a general system of irrigation as the most profitable investment the cultivator can make in a climate subject to such periods of drought as ours is known to be."

Burning.—In addition to winter burning the remedy can be used to good effect in other cases. For instance, where the attack of the bugs appears to be confined to a definite portion of the field, that portion should be overlaid with straw and burned, if not too large. Another pertinent suggestion is made by Dr. Thomas in Bulletin 5, U. S. E. C., and this has the indorsement of practical use by certain Illinois farmers. "If it is found at the time wheat is harvested that the bugs have not taken their departure, as is the case in the winter-wheat section, this fact may be taken advantage of to destroy a very large portion of them. If the wheat is at once threshed and the straw scattered over the stubble and burned, it will destroy all or most of those that

are there. I know of one section in southern Illinois where this has been practiced for a number of years by the German farmers, with good results." This remedy is very practical and doubtless can be used to good effect under such circumstances.

The following experiments in burning were made the past season at Ames, Iowa, by Professor Osborn, and the account is taken from his manuscript report:

On July 16 the stubble adjoining a corn-field was observed to contain large numbers of bugs traveling toward Corn. In the afternoon this migration was going on quite actively, and as the stubble was now quite dry it was fired with a view of destroying bugs remaining in it. Where tolerably thick, and when there was a fair breeze, it burned readily, but it was necessary to take some pains in carrying the flame along past thin spots to keep it from dying out. A considerable portion of the field, however, was successfully burned over, and the dead bodies of many bugs not completely consumed, which could easily be found on examining the burnt area, testified to the destruction of hosts of the pests. The bugs thus killed were mostly young larvæ, the majority of the adults and larger larvæ and the pupæ having already moved out. The number destroyed, however, must, I think, have well repaid the little trouble necessary to burn the stubble.

Early in August the bugs had so multiplied in a field of Hungarian grass that no further growth seemed probable, and most of the field was mown and the hay secured. A narrow strip, however, was left next the Corn, the plan being to burn this as soon as bugs began passing to the Corn. When the bugs started, however (August 13), the grass was not dry enough to burn except in spots. In such places as would burn, however, hosts of bugs were consumed. This strip was at once mown, and after drying a few hours another attempt made to burn it, as also on the following day; but portions were still too green to burn rapidly, and, unfortunately for the experiment, the two or three days following were not hot and dry enough to render it fit to burn readily. A few days later, however, on a dry day with a fair breeze, most of the strip remaining unburnt was burned over, and examination showed that great numbers of young bugs remaining were destroyed. Bugs, if under ground or secreted in roots of stubble, will not be killed; hence to destroy greatest numbers, as well as to secure most rapid burning, the fire should be started in the hottest part of a dry day, when bugs in greatest number will be moving.

PREVENTION OF MIGRATION—DIRECT REMEDIES DURING AND AFTER MIGRATION.—As has been so often pointed out, a great deal can be done in the way of destroying the insects at the time when they migrate from the wheat-fields, towards the close of the first generation, to Corn and other neighboring crops.

Ditching.—As long ago as LeBaron's first paper and as Fitch's second report, the method of digging a ditch or plowing a furrow around the infested field was in vogue. If a plowed furrow is made the perpendicular side should be towards the field to be protected and the furrow should be kept friable by dragging a log or brush occasionally through it, or, better still, a triangular weighted trough. The migrating bugs will fail to climb the side of the furrow and will fall back into it, where they can be covered with straw and burned. With care and activity the neighboring fields can be thus protected.

A modification of this plan appears in an unplaced newspaper cutting in our possession. It is as follows: "When they first appear, as they usually do, on the side of the corn-field, and before they have entered it, cut five or six rows of the corn and clear the ground; then plow a strip of land 8 or 10 feet wide, leaving a deep furrow in the center of the same. Then take the corn-stalks which were taken from the land and place them across the dead furrow and the trap is complete. When the bugs approach the field they will pass in under the corn placed across the dead furrow, and, preferring the shade and moisture, remain there until the stalks become perfectly dry,

when they can be put through a process of cremation that will prove effectual in destroying them. Should they first appear in the middle of a field of corn (as it not unfrequently happens they do), they can be surrounded on the foregoing plan and destroyed in the same way. This plan we consider the most practical of any that has come under our observation, and is corroborated to some extent by the experience of J. W. Martin, an observing farmer whose experiments are given in the Osage Mission (Kans.) Journal."

Tarred Boards or Tar alone.—The plan has been adopted and is recommended in the reports of Professor Riley and others of using common fence boards—6-inches wide and less—setting them upon edge and making a barrier of them around the infested fields, care being taken to cover the lower edge so that the bugs would not crawl under them. The upper edge is spread with fresh tar, which is occasionally renewed. Vast numbers are taken out from holes dug at intervals on the hitherside of the barrier in which the marching armies are collected. Commenting upon this remedy Professor Riley says: "With a little care to keep the tar moist by renewal, the boards may be dispensed with and the tar poured out of a kettle onto the ground. About a gallon is required to the rod, and it should be renewed every other day, oftener when rains prevail, until the bugs are destroyed." According to Dr. LeBaron this method was extensively used in the central part of Illinois, and especially in the vicinity of the Bloomington gas-works in 1872. He saw the operation performed near Bloomington where the tar was poured from an old tea-kettle on the ground along the exposed sides of a corn-field. This remedy, however, will seldom be used on account of its expense, except in such situations as that mentioned, where the tar can be readily and cheaply procured.

Sowing Strips of Plants distasteful to the Bugs around the Fields to be protected.—This remedy has been urged by certain authors and the crops to be used as barriers are preferably Flax, Hemp, Clover, or Buckwheat. The effect of this will be to deter and destroy the migrating individuals and cause the death of the young ones by starvation. It is, however, not a thorough remedy, and is not to be compared with the more direct remedies which cause the almost complete destruction of the insect.

Sowing Strips of favored Food around the Fields to be protected.—A strip of Timothy, Hungarian grass, or Millet may be sown around the corn-field to good advantage, with the object of entrapping the migrating bugs by plowing it under and burning the ground over when it has become filled with the migrating armies in transit. The bugs of the first generation which are full-grown will lay their eggs by preference in this protective strip, and these will be destroyed by the plowing and burning.

Hot Water and Soap-suds.—The application of strong soap-suds to the insects when gathered upon the outer rows of corn is recommended by a writer in the Southern Planter many years ago, and was also given by Dr. Fitch. Statement is made that a half gill or a gill poured upon each stalk will kill them all, and that the labor is not half so great as a single hoeing of the crop. Hot water has been recommended for a similar purpose by subsequent writers.

Kerosene emulsion.—A new and, under certain circumstances, very efficacious remedy for the Chinch Bug was introduced when Professor Riley, in 1882, first suggested to Professor Forbes the advisability of experimenting with this substance upon this insect. The results of

Professor Forbes' first experiments were published in Bulletin No. 2 of this Division (February, 1883), pages 23 to 25. The following solutions were used in these experiments:

"*Solutions with which dilutions were made.*—(1) Soap-suds, 1 pound soap to 10 gallons water; (2) soap-suds, 1 pound soap to 20 gallons water; (3) potash, 1 pound to 50 gallons water."

Emulsions as diluted.

	Per cent. of kerosene.
A. 2 parts kerosene, 1 part milk, 45 parts water	4
B. 1 part kerosene, 1 part milk, 18 parts water	5
C. 1 part kerosene, 1 part milk, 18 parts solution 1	5
D. 1 part kerosene, 1 part milk, 38 parts solution 2	$2\frac{1}{2}$
E. 1 part kerosene, 1 part milk, 38 parts water	$2\frac{1}{2}$
F. 1 part kerosene, 1 part milk, 38 parts solution 3	$2\frac{1}{2}$
G. 1 part kerosene, 1 part milk, 30 parts solution 2	3

All of these were efficacious. Fortunately, at the time when such application is to be made, viz, just after wheat harvest, help is abundant and the work can be done at a reasonable expense. Experiments made by Professor Forbes show that a simple mechanical mixture of 1 part of kerosene to 3 of water will kill the bugs and not injure half-grown corn, if it is kept constantly adjected. But the original soap emulsion, recommended so often in the reports of this Department, and made according to the formula originally proposed by Mr. Hubbard, will be much safer and will do thorough work. It will do no harm to repeat this formula:

Kerosene	2 gallons	= 67 per cent.
Common soap or whale-oil soap	$\frac{1}{2}$ pound	= 33 per cent.
Water	1 gallon	

Heat the solution of soap and add it boiling hot to the kerosene. Churn the mixture by means of a force-pump and spray-nozzle for five or ten minutes. The emulsion, if perfect, forms a cream which thickens on cooling, and should adhere without oiliness to the surface of glass. Dilute before using 1 part of the emulsion with 9 parts of cold water. The above formula gives 3 gallons of emulsion and makes, when diluted, 30 gallons of wash.

We realize the objections to recommending anything complicated in the way of a mixture and of apparatus for applying it, and in consequence we may state, as showing that an ingenious individual who is in earnest need not be hindered by lack of a proper apparatus for applying this mixture, the experience of Major R. S. Tucker, of Raleigh, N. C., as published in the News and Observer and in a special bulletin of the State department of agriculture, Raleigh, June 29, 1887. His letter stated, in brief, that, having tried a number of remedies, he learned of the kerosene emulsion at a time when the pest was most abundant upon the outer rows of corn; not having any force-pump or spray-nozzle with which to churn the emulsion he whipped the mixture in a large receptacle with a bunch of twigs for ten or fifteen minutes and then applied it to his outer rows of corn with a common water-sprinkler. The results were admirable, and certainly he deserved success for his trial.

Another practical test was made by Professor Atkinson, and reported upon in the bulletin just mentioned, as follows:

Mr. William F. Stroud, of Chapel Hill, had a field of Wheat which was infested with the Chinch Bugs. When the Wheat was harvested they immediately betook

themselves to the Corn, which was adjacent. Some of the corn-stalks for 1 foot or 18 inches above ground were literally black with the mass of insects, and sometimes when they could not be seen outside they were found in great numbers between the sheath of the blade and the stalk.

[Here follows the kerosene-soap emulsion formula just given.]

I found these proportions made the liquid a little weak, and I diluted in the proportion of six parts of cold water to one of the emulsion. The application of this to the Corn, June 25, was a perfect success in killing the bugs, and the Corn was examined later and was found to have sustained not the slightest injury.*

In my experiment I used a spraying apparatus, manufactured by A. H. Nixon, Dayton, Ohio, which consists of a square tank, which has a capacity of 8 gallons, with a force-pump hose and spray nozzel attached. This machine (called the Little Gem) was placed upon a rough sled made for the purpose, which was drawn between the rows by a mule.

As the spraying apparatus produced too wide a stream to apply the liquid rapidly and effectively to the stalks of Corn, I removed the spraying portion of the nozzle and used the part which produces a very narrow but strong stream (one-sixteenth of an inch in diameter). The liquid would run down the stalks and between the sheath of the blade and stalk, killing instantly the hundreds of insects with which it came in contact. The two rows were sprayed as far as the stream would reach on each side, and then the mule moved on to stop for another application. In this way the Corn was gone over very rapidly. Where a force-pump can be obtained it is better to apply it with this, but the nozzle should be very small, so as to throw a very narrow stream or spray directly against the stalk. If a force-pump can not be obtained, a common watering-pot, with a narrow nozzle, could be used very effectively. Several of these could be used, the operators going quite rapidly from one stalk or hill to another.

There is no reason why all should not get rid of the Chinch Bug on Corn, for a failure to kill the bugs would arise from some fault in the application, and the application can be made cheaper than a dressing of the Corn could be made with the hoe.

This application was made late in June, and Mr. Stroud reported several times later in the season that nothing more had been seen of the bugs, and Professor Atkinson, visiting the field October 17, found no Chinch Bugs in the corn-stalks where the emulsion was used, nor in the neighboring Crab-grass. Some were found, however, about 40 rods away in some late Corn, but they were few in number.

Professor Osborn's experiments with kerosene emulsions, made during the summer at our request at Ames, Iowa, are reported by him as follows:

A number of trials were made with kerosene emulsion first with a view to testing its value under various conditions, and afterward for the sake of checking the damage threatened to Corn.

The first trial was made July 15, the emulsion used being the common one, consisting of kerosene, soap, and water diluted to about 5 per cent. kerosene. The bugs were killed very quickly by this application, and great numbers of them could be reached, but many in particularly secreted places, in folds of leaves and under lumps of earth, escaped. Thrown on to the leaves and running down between leaf and stalk, it dislodged and killed immense numbers. Thrown against stalks where they were congregated it would quickly dislodge the mass, and while it was impossible to see whether all driven off in this way were sufficiently wet to kill them, it was certain that most of them were. This application was at the rate of about 1 gallon of emulsion or 12 gallons of the diluted mixture to 5 rows of Corn for 32 rods, or what would equal 5 gallons of emulsion, 60 gallons of diluted mixture to the acre, or a cost for material of less than 60 cents per acre. In trials of the emulsion diluted to range from 2 per cent. to 7 per cent. of kerosene, less than 4 or 5 per cent. was found to be unsatisfactory, and at the lowest figure bugs even when thoroughly drenched and kept for a time in the fluid were able to recover. A mixture (about 2 per cent., possibly a little less) which killed plant lice almost instantly, affected Chinch Bugs but slightly, if at all, and they afterward recovered and lived in confinement for many days.

*Professor Atkinson has since written that subsequent tests convinced him that one part of the emulsion to nine of water made the mixture quite strong enough.—L. O. H.

On August 15 applied kerosene emulsion to bugs accumulating on Corn, using an emulsion diluted to contain about 6 per cent. kerosene and spraying with cyclone nozzle. Great numbers of bugs could be found dead within a few minutes after application, and on the following day hosts of dead could be found on the ground around the hills treated. In places, however, the stalks had become well covered by live bugs that had moved in to fill the place of the slain.

Subsequently the farm department applied it on a larger scale, using 5 to 6 per cent. emulsion, and spraying from barrels in a wagon, one man working the force-pump and another manipulating the hose and cyclone nozzle, walking rapidly among the hills of Corn and directing the spray upon the masses of bugs. This resulted in the destruction of great numbers. In this application the cyclone nozzle was found by all means most satisfactory.

I suggested its trial to some of my correspondents, and one letter received in reply is of sufficient interest to be noted:

CAMBRIDGE, IOWA, *July* 20, 1887.

DEAR SIR: Your most satisfactory letter received some time since. The conclusion is a success; it was instant death to the Chinch Bugs. But it takes so much when you want to go over 5 or 6 acres that one can not stand the expense. It could be stood to go over it once or twice if I could have got the bugs all on the Corn, but they would a part stay on the Corn while the rest would lie under sods and anything else that would protect them from the sun. When your letter reached us they had left the Wheat (which they fully destroyed), and had gone into the Corn, which they killed for ten or twelve rows in some places, and some places not so far. Then they scattered over more territory for a time, but now they have left the Corn (almost), having flown away, I think. I am under obligations to you for your kindness.

Very respectfully,

J. E. WARREN.

Professor OSBORN,
Ames, Iowa.

The use of kerosene can hardly be expected to prove of value except when the bugs are massing on Corn. At this time, application to an acre or two of the field next to stubble may do much to save the rest of the field. By arranging nozzles with special reference to most efficient work in corn rows, and while Corn is small enough to drive a team in the field astride of one row, I think spraying can be done quite thoroughly at a cost of 30 to 40 cents per acre for material.

A cyclone nozzle, with pressure sufficient to do good work, discharges about 1 pint of liquid per minute. Adjusting three nozzles to play upon one row of Corn, one each side and one from above, and allowing teams to walk slowly 2 miles per hour, and it will take 30 gallons of liquid per acre, which, using 5 to 6 per cent. emulsion, costs about 30 cents, exclusive of labor, which for team and man an hour and a quarter would be about 40 cents more. First cost of force pump must, of course, be considered; the cost of labor on the farm, however, where the farmer uses his own team and does the managing of apparatus himself, might be counted less. By using only two nozzles or by driving faster the expense will be lessened.

BOGUS CHINCH BUGS.

Professor Riley figures and describes in his Seventh Missouri Report four species of Heteroptera which are frequently mistaken for the Chinch Bug and are often the cause of unnecessary alarm. We have reproduced the figures of these species upon Plate III. The first is the False Chinch Bug (*Nysius angustatus*, Uhl, fig. 9), which was frequently sent to Professor Riley. It is found all over the country, and occasionally damages certain crops quite seriously, Grape-vines, Strawberries, Potatoes, young Apple grafts, and all cruciferous plants. It is also very fond of Purslane, and, as mentioned elsewhere in this report, it is found in California congregating under *Polygonum*. It is the insect which caused the alarm in California in 1885. It was originally described by Mr. Uhler under the name given above, but was subsequently redescribed by Mr. William R. Howard as *Nysius raphani* and by Professor Riley as *Nysius destructor*, who cited Mr. Uhler's authority at the time for considering the form distinct.

The Insidious Flower-bug (*Triphleps insidiosus*, Say fig. 12) is another of these bogus Chinch Bugs. It is also a very wide-spread insect, and, so far from being injurious, it is one of the comparatively few insects which prey upon the Chinch Bug.

The Ash-gray Leaf-bug (*Piesma cinerea*, Say fig. 13) is another widespread species which occasionally damages grape blossoms in early spring, but lives principally upon forest trees and shrubs. This species is also often mistaken for our insect.

The Flea-like Negro-bug (*Corimelæna pulicaria*, Germ. fig. 14) is the fourth. Its appearance is more different from the Chinch Bug than any of the insects mentioned under this head, as is plainly shown by the figure. It feeds abundantly upon the fruit of the Raspberry and punctures also the stem of the Strawberry and the blossoms, leaves, and fruit-stems of the Cherry and Quince. It is also injurious to certain garden flowers and to certain weeds, among which Professor Riley mentions *Ceanothus americanus* and *Veronica peregrina*.

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[Correspondent writes from Indiana. Fitch gives account of habits and injuries, past history and nomenclature.]

1856. FITCH, ASA.—"*Micropus leucopterus.*" 2d Rep. Ins. N. Y., pp. 277–297, Plate IV, figs. 2 and 2a.

[Gives 1783 as date when first known as insect depredator on wheat in North Carolina; notes its occurrence at several times during next fifty years in such numbers as to nearly destroy the wheat crop; farmers ceased to plant wheat for a couple of years as only known remedy; alludes to drought which prevailed during period of injury, and their destruction by wet weather, 1840; first attracted attention in Western States 1840–'44; describes young larvæ; mentions briefly a number of varieties; gives history of nomenclature; suggests spraying infested fields as a practical remedy.]

1857. SIGNORET, V.—"*Micropus leucopterus,*" Say. Essai monographique du Genre Micropus; Spinola, Ann. Soc. Ent. de France, V, 3d series, p. 31.

[A technical description from specimens received from New York and Cuba.]

1861. WALSH, B. D.—"Chinch-bug." Insects injurious to vegetation in Illinois. Trans. Ill. State Agr. Soc., Vol. IV, 1859–'60, pp. 346–349.

[First notice of four Lady-bird enemies of the Chinch Bug. Figures *Hipp. maculata* and *Coccinella munda.*]

1862. HARRIS, T. W.—"*Rhyparochromus leucopterus.*" Insects injurious to vegetation. Third ed., pp. 197–200, fig. 84.

[See under 1852.]

1864. BUDD, JOSEPH L.—"Chinch Bugs." The best way to manage them. Prairie Farmer, July 16, 1864 [V. XXX], n. s., V–XIV, p. 36.

[Recommends early and thick sowing and rolling.]

Review by "Agricola," entitled "Another word about Chinch-bugs; how to use them." *Op. cit.*, July 23, p. 52.

Reply to Agricola's review, by J. L. Budd, entitled "Chinch-bug. Objection to deep covering of spring wheat." *Op. cit.*, August 6, p. 84.

1865. RILEY, C. V.—The Chinch Bug. Prairie Farmer, September 19, 1865.

[Exposes the fallacy of a reported observation by Mr. D. H. Sherman in the Waukegan Gazette, to the effect that the eggs are laid upon the wheat-head.]

1866. WALSH, B. D.—"Chinch-bugs." Practical Entomologist, Vol. I, p. 95.

[Prints a clipping from Prairie Farmer stating that the "bugs" had been successfully fenced out of a field by putting boards on edge around it and coating upper edge with coal-tar.]

1866. CANADA FARMER, December 1.—"The Chinch-bug."

[Occurrence of *Blissus leucopterus* hibernating at Grimsby, Ontario; account of habits and seasons; quotes Prairie Farmer for remedies.]

1866. RILEY, C. V.—"Chinch-bug." Prac. Ent., Vol. I, No. 6, p. 47.

[Exposes fallacy of a current theory that the eggs are deposited on the grain and fields become infested from its use; gives methods of depositing eggs and states that there are two generations in northern Illinois and possibly three in more southern latitudes.]

1866. WALSH, B. D.—"*Micropus* (*Lygœus*) *leucopterus.*" Pract. Ent., Vol. II, p. 21.

[Notices specimens of short-winged variety from Canada.]

1867. SHIMER, HENRY.—"*Micropus* (*Lygœus*) *leucopterus.*" Proc. Acad. Nat. Sci. Phila., Vol. XIX, pp. 75–80.

[Full journal account of observations during 1864–'65 in Illinois; conclusions as to causes of their destruction in 1865, p. 234; reference to epidemic.]

1869. WALSH AND RILEY.—"*Micropus leucopterus.*" Am. Ent., Vol. I, pp. 169–177, fig. 122.

[Popular inferences, past history, natural history, checks to multiplication; review of Dr. Shimer's prophecies about appearance.]

Ibid., pp. 194–199, figs. 138, 139.

[Predaceous foes of, damages done by, remedies for; summary of four conclusions: (1) They hibernate in imago stage in rubbish which should be burned; (2) early sowing in spring is an advantage; (3) compacting the soil acts as preventive; (4) heavy rains always injure or entirely destroy them.]

1869. PACKARD, A. S., Jr.—"*Blissus leucopterus.*" Guide to the Study of Insects, pp. 543, 544, fig. 547.

[Describes imago, life history, injuries of, epidemic diseases of 1865; cites its occurrence in Maine and at summit of Mount Washington; notices the theory that wet weather during breeding season is destructive to them.]

1870. RILEY, C. V.—"*Micropus leucopterus.*" 2d Rep. State Ent. Mo., pp. 15–37, figs. 1 and 2.

[An extended account and the best yet published; discusses past history, natural history, destructive powers, heavy rains, natural enemies, amount of damage, remedies, and bogus Chinch Bugs.]

1871. GLOVER, TOWNEND.—"*Rhyparochromus (Micropus) leucopterus.*" Rep. Com. Agr., 1870, p. 89.

[Refers to observations of others as to depositions of eggs, etc.]

1872. BETHUNE, C. J. S.—"*Micropus leucopterus.*" Rep. Ent. Soc. Ont., 1871, p. 55.

[Refers to accounts of early history, habits, enemies of, natural remedies, etc.]

1872. LEBARON, WM.—"*Micropus leucopterus.*" 2d Rep. State Ent. Ill., 1871, pp. 142–156.

[Estimates loss from depredations current year in Illinois, $10,500,000; treats of their prevention and destruction under five heads: (1) Natural enemies, (2) early sowing, (3) preventing migrations, (4) destroying by burning rubbish, (5) cease cultivating the affected crops.]

1872. GLOVER, TOWNEND.—"*Rhyparochromus leucopterus.*" Rep. Com. Agr., 1871, p. 84.

[Merely refers to its injuries in Western States, and mentions salt being used as a remedy.]

1872. LEBARON, WM.—"Chinch-bug." Experience of 1872. Prairie Farmer, August 24.

[Believes that a sufficient number of these insects hibernate under dead leaves in the woods to perpetuate the species; also that the wet spring of 1872 destroyed large numbers of the Chinch Bugs.]

1874. GLOVER, TOWNEND.—"*Micropus (Rhyparochromus) leucopterus.*" Rep. U. S. Comr. Agr., 1872, p. 121.

[Mentions injuries in Western States to Corn, Wheat, Sorghum, etc.; three broods reported observed in Missouri.]

1874. JOHNSON, B. F.—"Chinch-bug." Country Gentleman, Vol. XXXIX, p. 661.

[Abundant in central Illinois; stock was poisoned by eating fodder; suggests sowing plats of noxious plants, tobacco, nightshade, henbane, stramonium, hemp, etc., to assist in checking their ravages.]

1875. GLOVER, TOWNEND.—"*Micropus (Rhyparochromus) leucopterus.*" Rep. Com. Agr., 1874, pp. 127, 128.

[Gives localities in Southern and Western States where reported as injurious.]

1875. RILEY, C. V.—"*Micropus leucopterus.*" 7th Rep. State Ent. Mo., pp. 19–50; Appendix, pp. 51–71, figs. 2, 3, and 4.

[Résumé of previous history; full descriptions of various stages; natural history; extended account of injuries in 1874; exhaustive discussion of preventive measures and remedies; mentions irrigation; predaceous enemies. Appendix, correspondence of farmers.]

1875. RILEY, C. V. Locusts *vs.* Chinch Bugs. N. Y. Weekly Tribune, August 4, 1875.

[A letter from Lyons, France, remarking upon the abundance of Chinch Bugs and allaying fears as to great destruction by them.]

1876. UHLER, P. R.—"*Blissus leucopterus.*" List of Hemiptera of the region west of the Mississippi River, including those collected during the Hayden Explorations of 1873. Bulletin U. S. Geol. and Geog. Sur. Terr., I, second series. No. 2, p. 306.

[Mere mention, with a list of localities.]

1877. PACKARD, A. S., Jr.—"*Blissus leucopterus.*" 9th Rep. Geol. and Geog. Sur. Ter., 1875, pp. 697–699, fig. 4 and map.

[Refers to its destructiveness in the Western States; quotes estimates of different State entomologists; notices briefly some of the remedies for.]

1878. THOMAS, CYRUS.—"*Blissus leucopterus.*" 7th Rep. State Ent. Ill., pp. 40–71, 2 figs.

[Résumé of history, natural history, descriptions, etc.; two brooded in northern Illinois, possibly three in southern Illinois; remedies and general discussion of same.]

1879. RILEY, C. V.—Entomological notes. "The Chinch Bug." Farmer's Review (Chicago), February, 1879.

[Discusses weather influence and advances parallel between Rocky Mountain Locust and Chinch Bug; review of life history and summary of facts from Seventh Mo. Rept.; prediction of bugs in 1879 if weather prove dry.]

1879. THOMAS, CYRUS.—"*Blissus leucopterus.*" Bull. U. S. Ent. Com. No. 5. Ten figures, map showing distribution.

[Exhaustive résumé of present knowledge, with facts concerning injuries; natural history; predaceous enemies; full discussion of preventive and remedial measures.]

1880. KANSAS STATE BOARD OF AGRICULTURE.—Quarterly report for the quarter ending June 30, 1880. Topeka, July 20, p. 61.

[An account of damage to sorghum cane by the Chinch Bug.]

1880. THOMAS, CYRUS.—Temperature and rain-fall as affecting the Chinch-bug. Am. Ent., new series, Vol. I, pp. 240–242. with diagram.

[Condensation of his theory about periodicity of seasons of drough and their relation to appearance of this insect.]

1881. THOMAS CYRUS.—"The relation of meteorological conditions to insect development." 10th Rep. State Ent. Ill., pp. 47–59, with diagram.

[Discusses theory of septenary cycles of meterological conditions; believes it possible to predict with considerable certainty the season when Chinch Bugs will appear in injurious numbers.]

1881. RILEY, C. V.—Am. Nat., October, p. 820.

[Calls attention to the verification of Prof. Cyrus Thomas' prediction that this would be a bad Chinch-bug year.]

1881. RILEY, C. V.—Am. Agriculturist, November and December, 1881.

[Reviews natural history and remedies, and discusses the practicability of irrigation as a remedy.]

1882. HOWARD, L. O.—Rep. U. S. Dept. Agr., 1881–'82, p. 137.

[Mentions it as infesting rice affected by "white blast."]

1882. RILEY, C. V.—"Chinch-bug Notes." Rep. Com. U. S. Dept. Agr., 1881–'82, pp. 87–89.

[Calls attention to Professor Thomas' prediction of injury during 1881, and the fact that it was partially fulfilled; discusses briefly remedies and methods of prevention.]

1882. FORBES, S. A.—"Bacterium, a parasite of the Chinch-bug." Am. Nat., Vol. XVI, p. 824.

[Account of discovery of parasitic disease among Chinch Bugs.]

1882. FORBES, S. A.—"*Blissus leucopterus.*" 12th Rep. State Ent. Ill., pp. 32–63, Fig. 6.

[Gives full account of observations on life history, etc., for the year; insect enemies; a new insect enemy; bird enemies; account of observation on a bacterium parasite; experiments in drenching with water under artificial conditions not fully carried out; report of experiments with topical applications.]

1882. RILEY, C. V.—"The Chinch-bug." Am. Agriculturist, p. 476, 3 figs.

[General account of habits and natural history; meterological conditions affecting.]

1883. LINTNER, J. A.—Cir. No. 1, N. Y. St. Mus. Nat. Hist.

[Directions for arresting Chinch-bug invasion of northern New York.]

1883. LINTNER, J. A.—"The Chinch-bug in New York." Country Gentleman, November 8, 1883.

[Directions for co-operating among farmers to prevent ravages coming year.]

1883. FORBES, S. A.—"Experiments on Chinch-bug." U. S. Dept. Agr., Div. Ent., Bull. No. 2.

[Memoranda of experiments with kerosene emulsion and mixtures made at suggestion of Prof. Riley; found them quite effective.]

1883. FORBES, S. A.—Entomological notes of the season. State Dept. Agr. Cir. 106, Illinois crops for 1883, p. 177.

[Notes the deposition of eggs for first brood on the roots of Indian corn.]

1883. SAUNDERS, WM.—"*Micropus leucopterus.*" Rep. Ent. Soc. Ont., pp. 59–62.

[Account of appearance in New York; quotes from Lintner.]

1883. RILEY, C. V.—"Chinch-bug in New York." Science, Vol. II, 1883, p. 621.

[Cites facts to show that their appearance in New York is not an invasion, but extraordinary development of the species, dependent upon climatic conditions.]

1884. RILEY, C. V.—"The Chinch-bug in New York State." American Naturalist, January, 1884, XVIII, pp. 79, 80.

[A reprint of an unplaced article in Scientific American criticising Dr. Lintner's conclusions as to reasons for alarm in northern New York.]

1884. LINTNER, J. A.—Thirty-seventh Ann. Rep. N. Y. St. Mus. Nat. Hist., pp. 53–60.

[Not seen.]

1885. BRUNER, LAWRENCE.—"*Blissus leucopterus.*" Rep. Com. Agr. 1884, p. 399.

[Cites an instance where large numbers disappeared immediately after a heavy rain.]

1885. RILEY, C. V.—"Chinch-bug Notes." Rep. Comr. Agr. 1884, pp. 403–405.

[Refers to occurrence in New York, and considers that there is no cause for alarm; predicts they will attract no further notice.]

1885. FORBES, S. A.—Ent. Calendar. 14th Rep. St. Ent. Ill., pp. 4, 5.

[Notes on life history for year 1884.]

1885. LINTNER, J. A.—"*Blissus leucopterus.*" 2d Rep. State Ent. N. Y., pp. 148–164, figs. 37, 38, 39, and 40.

[Account of its occurrence in northern New York; résumé of its history, life history; remedial measures employed and recommended.]

1886. HUNT, THOMAS F.—"*Blissus leucopterus.*" Bibliography of insects injurious to corn. Misc. Essays on Economic Ent., Ill, St. Bd. Agr., 1885.

1886. WEBSTER. F. M.—"*Blissus leucopterus.*" Insects affecting fall wheat. Rept. of Ent., Ann. Rept. Comm. of Agr., 1885, p. 318.

[A brief record of Chinch-bug observations during the season; records a Mermis as a possible parasite.]

1886. FORBES, S. A.—"Chinch-bug in Illinois." Circular of information from the office of the State Entomologist.

1887. BRUNER, LAWRENCE.—Notes of the season. Bull. No. 13, Div. Ent., U. S. Dept. Agr., pp. 34, 35.

[Brief notices of their appearance in Western States in 1886.]

1887. FORBES, S. A.—The present condition and prospects of the Chinch-bug in Illinois for 1887–'88. Bull. No. 2 of the State Entomologist.

[Speaks of ravages for three years past, life history, food-plants; preventive remedial measures exhaustively discussed.]

THE CODLING MOTH.

(*Carpocapsa pomonella*, L.)

Order LEPIDOPTERA; family TORTRICIDÆ.

[PLATE II.]

By L. O. HOWARD.

INTRODUCTORY.

The Codling Moth is another of those important insects which have a vast newspaper literature and the habits of which are tolerably well known to most persons who suffer from their attacks, but of which there is, in present accessible form, no complete account. At the instance of Professor Riley, who has turned over to me all his notes and scraps, this article is therefore prepared, and its purpose is to bring into one readily-accessible article a review of the life history and a somewhat extended account of the remedies. Some new facts are introduced, and the latest experiments are summarized.

There is no insect injurious to fruits in this country, with the single exception of the Plum Curculio, which has been written about so largely as the Codling Moth. We had proposed adding a bibliographical list of the American writings, as in the case of the Chinch-bug, but soon found that it would consume altogether more space than could be allowed. References to the articles consulted will, however, be found in the text. The most important of them have been Professor Riley's, in the first, third, fourth, fifth, and sixth reports on the insects of Missouri; LeBaron's, in his second report as State Entomologist of Illinois; Dr. Trimble's, in his Insect Enemies of Fruit and Fruit Trees; and the more recent ones, treating of remedies only, by Chapin, A. J. Cook, and Forbes.

The familiarity of fruit-growers with the habits of the Codling Moth is hardly to be wondered at, in view of this multiplicity of literature, and to this familiarity is due the gradual improvement of the appearance of the apples found in market of late years. Before the use of the arsenical remedies it was a difficult thing for a single

fruit-grower to grow comparatively wormless apples without combining in the use of the band system with the orchardists of a neighborhood, on account of the inevitable restocking from adjoining orchards. Now, however, with the poisoned spray, the individual may keep his apples nearly perfect, no matter how careless his neighbors may be. The poisoning has the additional advantage over the bands that it prevents the damage of the brood to which it is applied, while the bands only capture the worms after they have done their damage, and thus lessen the numbers of the succeeding brood.

As in the preparation of the previous article, I have had free access to Professor Riley's notes, and to those of the Division.

GEOGRAPHICAL DISTRIBUTION.

The Codling Moth is originally a European insect, although it is now cosmopolitan. All of the European works on garden insects contain accounts of this species, which is called in most of the older ones *Tortrix pomonana*. It is an insect which is comparatively easy of importation from one country to another, on account of its wintering in the pupa state and of the habit which the larvæ have of creeping into crevices of all kinds to spin their cocoons; so that in trees, and more particularly in the cracks of the crates or boxes or barrels in which apples are shipped from one country to another, the insect finds a hiding-place and the little moth eventually appears. It has thus found its way all over the United States, making its first appearance in California, at Sacramento, in 1874. It is found in nearly all of the English colonies, in South Africa, in New Zealand, in Australia, and in Tasmania. There is no record of its occurrence in South America, although, in spite of the fact that it is a northern insect in appearance, it is found equally in Siberia, so far as apple culture extends, and in the sub-tropical region of northern Van Dieman's Land. In many of the English colonies it has only recently appeared, and the investigations and reports of special committees and the laws and regulations which have been enacted concerning it in these colonies would fill a large volume. It was introduced into America certainly before the beginning of the present century, but it is impossible to fix anything like an exact date.

THE INSECT POPULARLY DESCRIBED.

The larva is whitish when young, but becomes pinkish or flesh-colored as it approaches full growth (Plate II, figs. 1 and 5*a*). When young the head is blackish, but in the full-grown larva it is brown, with darker markings along the sutures. The shield on the back of the first segment is of the same color as the head. The body is furnished with a few very small hairs, which arise from minute elevated points, of which there are eight on each segment, two on the back each side of the middle line, and a somewhat larger one above and below each spiracle. The full-grown larva is from 15 to 18 millimeters long.

The cocoon is white inside and grayish outside, usually covered somewhat with bits of bark or minute fragments of whatever substance the worm happens to spin on. The inclosed pupa (Plate II, fig. 2) is yellowish brown, with rows of minute teeth on the back of the abdomen.

The moth (Plate II, figs. 3, 4, and 5) expands about 20 millimeters, and its general effect is grayish brown. Examining closely, we see that the fore-wings are marked with alternate irregular transverse streaks of gray and brown, and that there is a large, rounded tawny spot on the outer hind angle. This spot is marked with streaks of bronze or gold, and there are similar streaks just above it. The hind wings are brown, grading from light to dark from base to tip. The two sexes can be distinguished by a black pencil of hairs on the upper surface of the hind wing of the male only. This pencil is not easily distinguished, but is always present. It was first pointed out by Zeller in 1870, and arises not far from the base of the wing, near the median vein. It runs in a furrow, which is noticeable from the under side as a slight keel. This tuft not only separates the male from the female, but distinguishes *pomonella* from all other species of *Carpocapsa*, although it is found with the males of certain other genera (see Zeller in Stettiner Entomologische Zeitung, 1871, p. 55; and Riley, Third Rept. Ins. Mo., 103).

HABITS AND NATURAL HISTORY.

The habits and natural history of the species are practically the same the world over, although in England and Northern Europe, including Prussia, it seems to be single-brooded. In America it is two-brooded far north into Canada and in the South it is three-brooded. In Austria it is two-brooded, and its habits seem precisely the same as they are in this latitude. Attention has been called to the fact that in colder climates the cocoon is thicker than in warmer countries, but beyond some few differences of this sort the insect lives in the same way everywhere. The round of its life may be briefly summed up as follows: Soon after the blossoms have fallen and the fruit has begun to set, the moths issue from their cocoons in which they have wintered and which are usually situated in cracks in the bark of the trunk of the tree, when they pair and lay their eggs at the apex of the forming fruit.. In the little crumpled-up spot caused by the falling off of the calyx the eggs are hidden, sometimes two or three to a single apple or pear. The eggs are laid sometimes upon the smooth cheek of the apple and sometimes in the hollow at the stem, but these are both unusual. The young larvæ on hatching eat their way immediately to the core of the apple, where they live and grow, casting their skins four times, and excavate large and irregular cavities in and around the core, sometimes first eating the seeds. Their excrement is blackish and stains the cavities, which are also still further rendered unpalatable by the threads of silk which the little larva spins wherever it goes.

Usually the castings are pushed out through the hole by which the larva originally entered, and which is enlarged for this purpose from time to time. The infested apples can be detected thus by the mass of excremental pellets issuing from the end.

The larvæ reach full growth in about four weeks from the time of hatching, and the infested apples now begin to fall to the ground. The larva now bores a hole to the side of the apple and, issuing, crawls about for a suitable place to spin its cocoon and transform. In the great majority of instances it returns to the trunk of the tree, and crawling up some distance hides itself in a crevice under some partially detached bit of bark, where the thin, slazy-looking cocoon is spun. Occasionally the apples do not fall, and in this case the larva

on issuing crawls down the trunk instead of up, and usually spins at a higher point, nearer the crotch or even above it. The pupa state of this generation lasts but a short time, usually not more than two weeks. The moths then issue and begin to lay eggs for the second generation. It is estimated that each moth lays about fifty eggs, and these are developed rather slowly, so that the period of oviposition extends over ten days or two weeks. Dr. LeBaron found, on dissection, that while there were on an average fifty tolerably well-developed eggs in the ovaries, there were many others undeveloped, so that the number deposited by each moth may be increased.

Irregularity of development, combined with this slow oviposition, produces the overlapping of generations noticed in so many insects, and which becomes more prominent in insects which have several broods. About the same time full-grown larvæ, young larvæ, eggs, and pupæ will be found. So great does this irregularity occasionally become that moths of the first brood do not issue until on in September, and when the apples are picked they often contain larvæ only recently hatched. Such individuals are retarded, of course, in their growth by cold weather, and we have occasionally found larvæ in eating apples as late as the middle of January which were less than half grown, and one living specimen was brought to us in January 1888, which had not passed its second molt. It is quite likely that such individuals will successfully transform, and we believe that the appearance of their moths will not be greatly retarded beyond those of larvæ which spun their cocoons normally in the fall.

Seldom more than one larva is found in a single apple. When two are found they will usually be found to be of differing sizes, thus indicating that the eggs were laid by different moths. When of the same size, however, it has been noticed that originally the apple hung closely appressed to another, and that both larvæ, originally intended for different apples, by accident entered the same. Dr. S. F. Chapin, to whose careful examination of over three thousand infested apples we have referred in our section on remedies (see also Report Second Annual State Convention California Fruit-growers, 1882 [1883], page 18), found in this large number of apples containing the pest but twenty-four which contained two larvæ each, and one only which contained three larvæ. In but two apples were two larvæ found in the same cavity. The instinct of the moth which leads it to avoid apples already oviposited in and to deposit but one egg on a single apple is modified in confinement, and also probably wherever the moths occur in excess of the food supply. Professor Riley, in his manuscript notes, mentions that he placed a single apple in a breeding-jar with a number of moths, and that in a few days it was fairly riddled with young larvæ. The moth is a night flier and conceals itself by day, and as the oviposition is done by night it is seldom observed. Unlike most night fliers it is not readily attracted by light and is seldom captured by poisoned baits, as will be shown in another section.

The larvæ of the second generation are usually found in the later varieties of apples, and fewer of these fall to the ground in consequence of the insect than is the case with the early varieties. Many of the larvæ reach full growth before late fall and seek the same places for pupation as did the early brood. The cocoon of this brood is thicker than that of the first, as is to be expected, for in it they pass the winter. Often the crop is harvested before many larvæ have escaped for transformation, but the worms complete their

growth in the picked apples and issue just as though they had staid upon the tree, spinning their cocoons in this case in the barrel cracks or in any suitable dark niche or cranny at hand. After spinning its cocoon it does not immediately transform to pupa, but remains in the larval state within the cocoon until nearly spring, and in this inclosed hibernating condition it is by no means passively dormant, as Professor Riley observed during the winter of 1867–'68 that each time he cut open a cocoon to observe the condition of the larva it fastened up the incision.

An apparent exception to the rule that the insect hibernates as a larva was observed on certain specimens received at the Department November 15, 1883, from Mr. M. B. Newman, of Wyandotte, Kans., and which were already in the pupa state on receipt, and in fact when sent (November 12). From these pupæ, which were kept in a comparatively warm room, two moths issued January 8, 1884, and two more January 14. The same gentleman stated, on the authority of Mr. R. B. Armstrong and other orchardists near Wyandotte, that large numbers of dead Codling Moth larvæ were found under the loose bark of the apple trees during October, and which had doubtless been killed by the cold drenching rains which prevailed at that time. We were unable to secure specimens for identification, however, and the statement must remain unverified.

The cocoons of this brood are often found between the staves and hubs of apple barrels. Hundreds can be sometimes found in such locations.

It may be of interest to state that in North Germany, where the insect is single-brooded, the moths make their appearance and deposit their eggs from the middle of June on into July.

FOOD PLANTS.

Although the Codling Moth is above all an apple pest, it is quite a general feeder, and is found in other seed fruits of the same family, such as pears and haws. The stone fruits of the family Rosaceæ are less infested than the others, although it is sometimes found quite abundantly in peaches, and instances are on record showing that it does considerable damage to plums in some localities. Apricots are also infested. It has also been found in Europe in all of these fruits. Outside of the fruits of the family Rosaceæ, however, it is not known in this country.

There are, however, several European records of the occurrence of this insect in walnuts and oak-galls to which we may properly give some consideration. The first of these records appears in a paper by Laboulbène in the Annales de la Societé Entomologique de France, 5th series, Vol. I, 1871, page 295, from which we translate the following paragraphs:

"The shell of the nuts deprived of the green envelope shows often at the point of attachment a blackish hole. The two halves separated show the kernel gnawed and a great quantity of brownish grains made by the excrement of a larva. Moreover, the substance of the nut or the kernel has in places a dark tint, and occasionally the tissue has been spoiled, shriveled, or covered with mold. Finally, in several fruits I have noticed on careful examination silk threads among the brownish excremental pellets.

"I found two whitish worms of medium size with chitinous head and six legs, which are certainly caterpillars. I attributed to these

the silk threads and the excrement which filled the injured nuts. The orifice in the hilum of the nuts was also produced by these caterpillars in the act of leaving the fruit to transform outside.

"But there was also, besides the two caterpillars, a great number of reddish maroon pupæ, which could only belong to a dipterous insect. These were found everywhere in the cavity of the spoiled nuts. At the end of two weeks there issued a number of small black flies. These all belonged to the same species (*Siphonella nucis*) which M. E. Perris made known for the first time in our Annales more than thirty years ago, accompanying his work by numerous figures.

"I have not seen the larvæ of the *Siphonella*, but M. Charles Robin has seen them in the wormy nuts. These larvæ transformed to pupæ during the journey from the Department of the Ain to Paris.

"I confided to the care of M. J. Fallou the two caterpillars mentioned. One of them after pupating produced *Carpocapsa pomonana*.

"* * * In my opinion the larva of *Siphonella nucis* lives upon spoiled material, perhaps upon the excrement of other larvæ, and is not to be relegated to the same rank as the *Carpocapsa* for the damage which it causes. M. Perris has distinctly stated that it is not a parasite; it lives by the damage done by the *Carpocapsa*, which is in reality the principal author of the injuries which render the nuts worm-eaten."

The fact that this insect was a true Codling Moth rests entirely upon the determination of Mr. Fallou. On referring to the bulletin of the same society for December 27, 1871, page 85, we find that Laboulbène stated that the specimen bred by Mr. Fallou was destroyed during the sack of the city of Chateaudun by the German army. In speaking of it he makes use of the following somewhat significant sentences: "This Lepidopter was so near *Carpocapsa pomonana*, Hübner (*pomonella*, L.), that it was referred to this species. However, to make sure, Mr. Fallou sent it to Mr. Guenée, who is so great an authority upon such matters. We know what became of the specimen. In order to state positively that the lepidopterous insect injurious to walnuts is the same as that which injures our apples it will be necessary to raise a great number and so determine it irrefutably. I call this fact to the attention of competent entomologists."

Even in this state of comparative doubt, however, the fact seems to have been accepted by other entomologists. The record is quoted without question in the Zoölogical Record for 1871, page 380.

In the Entomologist's Monthly Magazine, Vol. XV (1874), page 13, Mr. C. G. Barret states that Mr. W. West "tells him that he has reared the perfect insect [*C. pomonella*] from a larva which he found feeding in a walnut. Without intending a slur upon Mr. West's competency, we may simply draw attention to the fact that this determination does not seem to have been verified by any well-known entomologist.

In the bulletin of the Societé Entomologique de France for May 10, 1876, Mr. Ragonot makes the similar statement that this insect has been reared from walnuts, although he does not give it as a personal observation, and it is probably simply a reference to Mr. Fallou's rearing.

The probability of a uniformity of habit in this species must be our excuse for endeavoring to show that these observations are not well supported, and we may refer to the fact that a closely allied species (*Carpocapsa putaminana*, Staud.) seems to be quite well

known to feed upon walnuts in the way described by Laboulbène in Brussa, Andalusia, and in Italy, also in Austria. The larva of this insect was taken by Zeller while in Italy for that of *pomonella*, but in the Stettiner Entomologische Zeitung for 1871, Vol. XXXII, pages 55, 56, he states that it belongs rather to Staudinger's *putaminana*. This, of course, immediately suggests the possibility of a mistake in determination on the part of Messrs. Fallou and West. The Fallou specimen has been destroyed as above stated, but if the West specimen is still in existence we would urge the importance of examination of it upon English entomologists.

The oak-gall observation is recorded by Ragonot (*loc. cit.*). It seems that Mr. Bonnaire had collected a number of oak apples (galls of *Cynips quercus-folii*) in the autumn, and that in the following spring there appeared a single Codling Moth in addition to the usual tenants of these galls. Mr. Bonnaire affirmed that his box contained nothing but these galls. Ragonot makes no comments upon this statement, but his silence seems to accept the fact. It seems to us, however, rather unlikely, and it is possible that the *Carpocapsa* larva in seeking a place to spin its cocoon had either found its way into a broken gall before the collecting, or, emerging from a picked apple, had found some crevice in the box a convenient place for its cocoon. We can hardly believe that it fed and developed on the gall substance.

NATURAL ENEMIES.

Almost all orchard birds will feed upon the Codling Moth in one state or another. The Woodpeckers and the Creepers and the Black-capped Titmouse which run up and down the bark of a tree find the cocoons in the crevices and quickly rob them of the inclosed pupæ. The Downy Woodpecker (*Dryobates pubescens*) and the Chickadee (*Parus atricapillus*) have been shot by Trimble and proven by their stomach contents to feed upon the Codling Moth larva.

A hair snake (*Mermis acuminata*, Siebold) has been found by several observers in this country coiled around in the core of infested apples, and undoubtedly infests the larva of the Codling Moth. Professor Riley has five specimens from this source, varying from 5 to 8 inches in length. This species, which is considered by certain European authors as but a parasitic, non-sexual form of *Mermis albicans*, has been taken from several different insects in addition to the Codling Moth (see 1st Rep. U. S. Entomological Commission, 1877, p. 327). It was first determined from the apple-inhabiting individuals by Dr. Leidy (see Proc. Acad. Nat. Sc. Phil., XXVII, 1875, p. 15), who had mentioned the same worm in the proceedings of the same society for 1850, p. 117, as obtained from a child's mouth. In his 1875 paper he explained this latter occurrence on the ground that the child had probably eaten an infected apple. This *Mermis* has been taken also by Mr. P. H. Foster, of Babylon, L. I., directly from Codling Moth larvæ found concealed under bands.

Of true hymenopterous parasites at least three species have been recorded in Europe and two have been bred in this country. The European species are *Phygadeuon brevis*, Grav., *Pachymerus vulnerator*, and *Campoplex pomorum*, Ratz., all Ichneumonids. The species which infest it in this country are also Ichneumonids and are *Pimpla annulipes*, Br., (Plate II, Fig. 7,) and *Macrocentrus delicatus*, Cress., (Plate II, Fig. 8.). Both of these insects were first recorded by Professor Riley, who reared them from the Codling Moth in Mis-

souri in 1872. The *Pimpla* is quite a wide-spread species in all parts of the country and is not by any means confined to the Codling Moth. Professor Riley has recorded it from the Walnut Case-bearer (*Acrobasis juglandis*) and has also reared it from the Cotton Worm of the South (*Aletia xylina*) and from *Grapholitha olivaceana*, Riley, *Coleophora cinerella*, Cham., *Orgyia leucostigma*, Har., and an unknown leaf-roller on Ash. It does not seem to spin a cocoon, but eats its way out of the pupa in which it has transformed, usually coming out of the anterior part.

Recently it has been sent to us from Alameda, Cal., where it was reared from the Codling Moth pupa by Mr. Koebele. The *Macrocentrus* is, so far as we know, confined to this one host. It is apparently a more efficient destroyer of the pest than is the *Pimpla*. We have seen large series of individuals in several collections and it is as common at the East as it is in the West. It spins a tough brown cocoon within that of the *Carpocapsa*.

There are a great many predaceous insects which feed upon the larvæ while they are searching for suitable places to spin up, and upon the pupæ, which are poorly protected by the delicate cocoon. None, so far as we know, seek the larva in the apple. Professor Riley states that the Pennsylvania Soldier-beetle (*Chauliognathus pennsylvanicus* DeG., Plate III, fig. 15) and the Two-lined Soldier-beetle (*Telephorus bilineatus*, Say) in their larval states feed upon the larvæ of the Codling Moth after they have issued from the apples. He also mentions the fact that the larvæ of a species of *Trogosita* also helps in this good work. Dr. LeBaron treats of this insect at some length, but of late years it has not been found. The species has never been determined. Mr. Koebele has recently sent us from California two Dermestid beetles, which are stated to destroy the pupæ of the Codling Moth. These are *Trogoderma tarsale* and *Perimegatoma variegatum*. Experiments made indicate that they will kill the chrysalids in confinement, but as to destroying them in the open air on trees we have no absolute evidence. Mr. Keobele has, however, been instructed to make close observations upon this point. An undetermined Soldier-bug was observed by Mr. G. W. Shaw, a correspondent of Dr. LeBaron's, who states that he has actually observed the bug to pierce an apple with its beak and draw out the apple-worm, which, however, is a statement which may be taken with a great deal of allowance. An unbred and undetermined coleopterous larva was received by Professor Riley in 1874 from Prof. A. J. Cook, with the statement that it fed upon both larvæ and pupæ of *Carpocapsa pomonella*. This larva, according to Professor Riley's notes, bore a close resemblance to that of the Clerid *Necrobia rufipes*—the Red-legged Ham-beetle.

REMEDIES.

Under this head we shall discuss only such methods as are of considerable practical utility, not dwelling upon the methods which have been proven by experience to be of little avail. The remedies here considered, viz, the destruction of windfalls—feeding and trampling—the use of sheep and hogs, jarring or picking, confining the moths which issue in store-rooms, store-houses, or barns, the bandage traps, and the use of arsenical mixtures, are all simple and more or less effective. In a badly-infested orchard all could be used to good advantage.

THE DESTRUCTION OF WINDFALLS.—FEEDING AND TRAMPLING—THE USE OF SHEEP AND HOGS.—This remedy is one of the oldest in use and may be used with good results. There is no question but that a great many of the larvæ which fall with the apples, which we have elsewhere shown constitute the larger proportion, are destroyed by stock pastured in this way. We can do no better under this head than re-produce one of the best of the many accounts by men who have tried this method. This is a statement by Mr. J. S. Woodward in the New York Weekly Tribune for June 9, 1880:

"My apple orchard covers 32 acres of ground, and in addition to making a run for some 30 hogs, I have during the past two years kept from 150 to 200 sheep and lambs in it during the summer. I have just brought the sheep (May 21) and turned them in for this season. Of course that amount of land, if it was in good seeding and free from trees, would not pasture so much stock, but in addition to the pasture, I feed enough grain and wheat bran to keep them in such condition that the lambs shall be large enough to wean in July, and the sheep sufficiently thrifty to at once accept the buck after weaning the lambs, and thus drop their next lambs for early winter feeding next winter.

"This, I find, costs me less than to hire the same number pastured by the week, and being crowded they eat every fallen apple as soon as dropped; for the latter purpose I find sheep much better than hogs, for while the hogs sleep so soundly as not to hear an apple drop if only a few feet away, a sheep never sleeps, so that it is on hand for every apple as soon as it touches the ground.

"I let them run here until time to gather winter fruit, and although they will eat a few apples and a few twigs from the ends of the lower limbs, as they bend down with the load of fruit, I find my fruit each year growing fairer, with less and less wormy apples, and my trees, manured with the feeding of so much grain, are looking remarkably healthy and are productive. To prevent their gnawing the smaller trees I wash the trunks with a solution of soap-suds, whale-oil soap, and sheep manure about once each month, and besides I give the sheep a constant and full supply of fresh water; this is very important, for in hot weather they get very thirsty, and will eat the bark from the largest trees even, unless they have plenty of water.

"I like this manner of treating my orchard very much. What it would cost me to hire the sheep pastured each week will buy at least 600 pounds of bran and 400 pounds of corn, making an aggregate each summer of over 10 tons of the very best kind of fertilizer for an orchard. For the money I pay for feed I get my sheep kept in the finest condition, have the lambs growing finely all summer, and have the whole amount of feed bought (which is worth all it costs for that purpose) scattered about the orchard in the best possible condition and manner. Thus, you see, I prove that it is perfectly practicable to 'eat my cake and have it, too,' or, in other words, to get twice value received for the money invested, besides having the Codling Moth successfully trapped."

Where it is inconvenient or impossible to pasture sheep or hogs in an orchard, the immediate collecting of windfalls by hand, in which the services of children can be utilized, is often a valuable adjunct to the use of the band system.

JARRING OR PICKING INFESTED FRUIT FROM THE TREES.—The plan of jarring the trees or of knocking off or picking the infested fruit has been practiced by some orchardists with considerable suc-

cess. It is, however, a laborious method when compared with either the band system or with the early spraying of the trees, and is only of practical utility in very small orchards, or where only a few choice trees are to be protected, as in a door-yard. Mr. Oliver Chapin, of East Bloomfield, N. Y., as reported by Professor Riley in his Fourth Report on the Insects of Missouri, p. 26, was accustomed to send two men with poles through the orchard, who directly tapped those apples from the tip of which the excrement of the worm could be seen exuding. A boy collected the apples and afterwards threw them into a stream or into a kettle of hot water. This was done from the middle of July on. Professor Riley urged a general jarring of the trees with a rubber-tipped mallet or pole earlier in the season, and also suggested boiling the fruit and feeding it to hogs.

Mr. Barnes, of Bloomingdale, Ill., according to Dr. LeBaron, adopted the method of picking off the apples which appeared to be infested, by means of a wire hook attached to a long pole, and picking with the aid of ladders was resorted to as supplementary to the destruction of windfalls and the use of bands by Dr. Chapin in California, as we have related in another section of this article.

KILLING THE MOTH.—Although the destruction of the moth has received some attention, there is really but one suggestion to make which is of any importance, and that is as follows:

Inasmuch as many apples are picked in the fall before the worms have emerged for pupation, the larvæ must spin their cocoons in or near the receptacle in which the apples are stored for the winter, and consequently the moths must issue in spring in considerable numbers in the cellars or store-rooms where the fruit is kept. Flying out through open windows or doors, they naturally make their way to the orchard and start a numerous progeny. It becomes necessary then in May, June, and July, and earlier, according to locality, to keep the doors and windows of such store-rooms tightly closed, or, better still, fit them with wire screens.

Observations made during 1882 by Miss Alice B. Walton, at Muscatine, Iowa, showed that the insects wintering in cocoons in apple barrels in the cellar remained in the larva state, in one instance at least, as late as June 29, upon which date it changed to pupa. The moths emerged in her cellar from June 27 to July 13, although at the latter date outside worms from early out-door moths had become full grown and the apples had begun to fall. From two apple barrels she raised "between three and four dozen moths," which well illustrates the necessity for some measure to prevent their escape. Where it is possible and easy, changing the barrels and treating the old ones with hot water will accomplish the result and avoid the necessity for screens, and barrels which have been emptied during the winter should always be so treated.

The observations on this point made by Mr. F. C. DeLong, of Marin, Cal., are of great interest and place in the strongest light the necessity for a thorough scalding of the barrels, boxes, or crates, and of screens for the windows of the store-house or barn. It seems that on the Novato Ranch there are 31,000 trees on 250 acres of land, and that the Codling Moth was not noticed there until June, 1881, when Mr. Matthew Cooke discovered a single pupa. Later the fruit was gathered and carried into the apple house, very few affected apples being noticed. During the winter months Mr. DeLong had mosquito netting put over all of the windows, and nailed up all of the doors except one, the key of which he put in the possession of a

trusty man. The moths began to appear about the middle of April, and up to May 27, 2,671 had been killed and counted. From May 28 on a daily count was kept, and the moths issued in great numbers until nearly the end of August. The number caught and killed altogether by Mr. DeLong's assistant was 15,627, and the highest catch for a single day was 990 on June 15.* It transpired, moreover, in the discussion of this statement, that a large number of bats were accidentally shut into this same apple house and that doubtless many additional Codling Moths were killed by these insectivorous creatures.

The accounts of the capture of the moths with baits of diluted vinegar and molasses and with other similar substances and at light, which have occasionally appeared, are probably the results of mistaken identity, as are also in all probability the accounts of the capture of the moth by plants of the genus *Physianthus*, which have recently attracted much attention in New Zealand and California. The insect-catching properties of the flowers of the different species of *Physianthus* have long been known, but we very much doubt whether Codling Moths are ever extensively caught by these flowers. Dr. Le Baron observed the moths feeding upon moist sugar and slices of apple in confinement, but they have never been found frequenting flowers or feeding out-of-doors in a state of nature. Professor Riley has treated of the *Physianthus* plant in the Transactions of the Saint Louis Academy of Science, vol. III, p. cxv, and in the American Entomologist, vol. III, p. 75 (March, 1880), and we may add that he now states, after fifteen years' experience with this plant, he has never found that it has captured a Codling Moth, even where grown close to apple orchards. Officially attention was called to this *Physianthus* matter by J. T. Campbell, United States consul at Auckland, New Zealand, who was interested in it through Dr. Cheeseman, of the Auckland Museum, with whom the various reports published the past summer by the Country Gentleman, Prairie Farmer, and other papers originated. After receiving Mr. Campbell's dispatch through the State Department we wrote him, urging him to make certain, in the first place, that there were actual Codling Moths among those captured by the flowers, and, in the second place, if there were such, to examine them carefully to determine whether they were males or females, and if the latter, whether they had oviposited. Mr. Campbell replied that, while he could state positively that the moths found in the flowers were Codling Moths, no examination had been made to determine sex or the relation of the time of capture to time of oviposition. We have since received a very large number of specimens from him, but among them not a single Codling Moth and not even a single Tortricid. All were unrecognizable Noctuids and Pyralids. It is proposed to train these vines up the trunks of apple trees with the surmise that the flowers, by capturing the moths, will protect the crop.

In summarizing the whole question of the possibility of attracting the moth we can not do better than quote the two following paragraphs from Professor Riley's Fourth Report on the Insects of Missouri, p. 27, as it so effectually answers the many published suggestions to the effect that such remedies are practicable:

"I have elsewhere given it as my decided opinion that neither fires, lights, or bottles of sweetened water, vinegar, or of any other liquid,

* See Official Rep. 2d Ann. State Conv. Cal. Fruit-growers, San Francisco, 1883, p. 21.

can be used with any degree of success in fighting the Codling Moth, and I have good reasons for so doing. During one whole summer, three years ago, I had a patent moth-catcher constantly in a garden surrounded by several old apple trees badly infested with this insect, and I never caught a single specimen of *Carpocapsa pomonella*. The trap was made of bright tin, with an inverted cone so placed in a basin that I could attach a light and fill the basin with sweetened fluid. Again, during the summer of 1870, I was in the habit of working till late at night in an office surrounded by apple orchards known to be badly infested. I worked by the aid of two large kerosene lamps, each having a strong reflector, and the light in the room was so bright as to form a constant subject of conversation among the neighbors. Insects of one kind and another would fly into the room by hundreds, and on certain warm, moist evenings would beat against the windows with such rapidity as to remind one of the pattering of rain. Yet, during that whole summer I caught but one or two Codling Moths in that room, and there was more reason to believe that they had bred in the house than that they were attracted from without.

"At the same time I had hung up in an orchard close by, many wide-mouthed bottles, half-filled with various liquids, such as diluted sirup, sugar water, and vinegar more or less diluted. Every two or three days these bottles would contain great numbers of insects, which were critically examined. Many of them would be small moths of one kind and another; some of them larger moths, known to be injurious, and many other insects—such as beetles, true bugs, wasps and two-winged flies—that were beneficial. Indeed, there were almost as many beneficial as injurious species, and, as I shall presently show, the only two species yet known to prey on *Carpocapsa pomonella* were among the more numerous victims of these hanging bottles. From my notes I find that but three Codling Moths were caught in these bottles during the summer. Indeed, so small is the proportion of Codling Moths which I have caught by the above-mentioned process, that the chances of their accidentally flying into such situations are about as great as of their being attracted. I might add further experience on this head, but it is unnecessary. Upon showing specimens of the Codling Moth to many dozens of eminent and intelligent fruit-growers who have had to do with apple orchards, and consequently with apple worms, most of their lives, I have seldom found one who did not candidly confess that he had never before identified the insect; and under these circumstances it is not surprising that other similar moths should have been mistaken for the genuine article. The moth is, therefore, occasionally caught in such traps, and in the face of other intelligent testimony the fact can not be denied, though the experience on this head of non-entomologists is conflicting. But whether we consider that the few so caught are really attracted, or are captured accidentally, I believe that the methods indicated have no practical value. They are blind ways of shirking the more sure and efficient remedies.

"I have been thus explicit as to these would-be remedies because my statement 'that the Codling Moth was not attracted (to any extent) by light' has been recently quoted by Mr. J. W. Robson as an evidence 'that scientific men don't know everything.' It would be strange indeed if they did, and I have already labored under the impression, somehow or other, that they were the last to claim any such universal knowledge, and that it was the charlatan alone who

was blessed with the knowledge of everything. In the latest work on apple culture that has been given to the public, namely, 'The Apple Culturist, with illustrations, by S. E. Todd,' we naturally look for all that is new and important about this insect which cuts such a figure in apple culture. Alas! what do we find? The descriptive part is a perfect plagiarism, almost word for word, from an article in the American Entomologist (Vol. I, pp. 112–114), all palmed off as original; while under the head of remedies, he concludes his advice as follows: 'By keeping the bottles containing sweetened water and the pan half filled with thin molasses, with a lighted lamp near it in the orchard every night, in good order, almost every insect will be trapped in a few days,' and this excellent (!) advice is accompanied by an illustration of a shallow pan with a kerosene lamp on one edge of it, and 'flies' as thick as a swarm of bees around it."

TRAPPING THE WORM—BANDAGES, SHINGLE TRAPS, ETC.—The fact that the larva of the Codling Moth preferably seeks shelter under loose bark and in crevices on the trunk of the tree before spinning its cocoon long ago gave rise to the practice of affording it for spinning artificial shelter, which can be readily examined and in which the insect can be readily destroyed. The first notice of the adoption of such a plan which we have found is by Mr. Joseph Burrelle, of Quincy, Mass., published in the New England Farmer (Vol. XIX, 1840), in which he says, according to Harris, "that if any old cloth is wound around or hung on the crotches of the trees the apple-worms will conceal themselves therein, and by this means thousands of them may be obtained and destroyed from the time when they first begin to leave the apples until the fruit is gathered."

To Dr. I. P. Trimble is generally given the credit for the discovery of the hay band so long used for this purpose, and it is generally known as the "Trimble hay-band system." It is a natural outgrowth of the practice mentioned by Mr. Burrelle. Dr. Trimble, in 1862 or 1863, found an old boot-leg in the crotch of a neighbor's pear tree, and upon examining it he found 16 cocoons of the Codling Moth in its folds. This started his experiments, which were made with leather (chamois skin), old carpet, cloths, and hay rope. His experimentation resulted in his unhesitating recommendation of hay rope wound around the tree in three coils at some little distance from the ground. He also advised the application of other bands to the larger limbs. The rope was fastened as tightly as it could be pulled, and in examining it he simply pushed it up the trunk, replacing it after destroying the cocoons.

Professor Riley, in his First Report on the Insects of Missouri, laid down the following rules concerning the hay-band system: "First, the hay band should be placed around the tree by the 1st of June, and kept on till every apple is off the tree; second, it should be pushed up or down, and the worms and chrysalids crushed that were under it every week, or at the very least every two weeks; third, the trunk of the tree should be kept free from old rough bark, so as to give the worms no other place to shelter; and, fourth, the ground itself should be kept free from rubbish." In his fourth report he advises applying the bands two weeks prior to June 1.

In his fifth report he describes a band somewhat superior to the simple strip of 6-inch wide canvas mentioned in his fourth. It consisted of a strip of old sacking 4 inches wide and lined on one side with pieces of lath, tacked on transversely and at such a distance

from each other that when brought around the tree they formed an almost complete wooden ring.

The Wier shingle trap was patented and put on the market in 1870 or 1871. It consists of three shingles placed at a slight distance from each other on a large screw, which is to be forced into the trunk of the tree. The idea is that the worms descending or ascending the tree and meeting the shingles will crawl between them. The shingles being mounted on a screw can be easily turned apart and examined. This trap is mentioned on account of the interest which it aroused at the time. Experiments which Professor Riley made during the summer of 1872 showed that the lathed canvas just mentioned secured on an average five times as many worms as any single Wier trap, and the rag, paper, and hay bandages all much more than any single Wier trap. A crucial experiment was tried by Dr. LeBaron, who, on each of four trees, put two of the Wier traps on opposite sides of the tree, one higher than the other, so as to admit of a carpet band between them. The result was:

Number of worms in upper traps	36
Number of worms in lower traps	44
Number of worms in cloth bands	188

The relative advantage of cloth bands in different positions, and the desirability of having two bands on the same tree, is also shown by Dr. LeBaron in a five-tree experiment, which we condense into the following table. One band was placed from 1½ feet to 2 feet above the other:

Number of worms in upper bands	282
Number of worms in lower bands	350

In nearly every case the lowest bands contained the most, while bands which were placed on some of the largest limbs captured very few after the middle of August, although quite a number in late July and early August.

There can be no question but that thorough use of trap bands will bring about admirable results, especially if neighbors unite. Professor Riley, in 1879, stated that he had no doubt but that the marked improvement in the Michigan apples noticeable at that time was due to the quite general use of bands in that State, brought about by the publications and lectures of a few enlightened men, and particularly by the discussions at the State Horticultural Society.

The larvæ captured under bands have been counted and tabulated, and the improvement in the character of the fruit has been noticed and recorded, but the only attempt with which we are familiar to ascertain and tabulate the exact proportion between the worms on a tree and those caught by the bands was that made by Mr. E. J. Wickson at the Agricultural Experiment Station at the University of California, during the summer of 1887. The results are given in Bulletin No. 75 of the Station, and indicate that while from a total of 457 apple and pear trees bandaged 2,704 apples and pears were found from which the worms had escaped, only 1,188 worms were collected from the bands, or 44 per cent. of the whole. The bands used were strips of old sacks, 5 or 6 inches wide, allowed to lap over well and tied with a string around the middle. It seems that but one band was allowed to each tree, presumably fastened at the middle of the trunk, and that they were examined once a week. The recorder states that he believes that many of the worms which issued from the apples and did not find their way to the bands were eaten by birds which were always working over the ground while he was in the orchard.

The others it was thought must have transformed under clods of earth, as there was no loose bark on the trees and no rubbish on the ground. Undoubtedly many, if not the majority, of those not found in the bands perished without transforming. Moreover, inasmuch as one worm often injures two adjoining apples or pears, the number of infested fruit is not necessarily indicative of the number of worms, although as occasionally more than one worm is found in a single apple, it is reasonably safe to assume that it is indicative. From what we know of the habits of the insect it seems that the latter happens less often than the former. Better results would also have doubtless been obtained had two bands been applied, one a foot or two from the ground and one near the crotch. However, just as it stands, 44 per cent. killed is a good showing, and as Mr. Wickson well says, "the destruction of this proportion of fully fed and healthy larvæ must be considered very satisfactory," and "it will be seen that the old method of treatment is still one of the most effective that can be employed."

The very thorough endeavors made by Dr. S. F. Chapin in California in 1882 are also interesting and deserve mention here. His results were admirable, but were only accomplished by the most careful and painstaking labor. Three methods were adopted. After July 10 he commenced a systematic examination of all fruit upon the apple and pear trees by means of a ladder, and every apple or pear found infested was picked and reserved for examination and destruction. Bands were placed upon 800 trees, and these were examined closely every week, and all larvæ found were counted and destroyed. All fallen fruit was immediately gathered and examined, and afterwards destroyed. So carefully was this done that at picking time the men were only able to discover about 200 infested fruit. His table is interesting on many accounts, and is reproduced:

Date.	Infested fruit picked from trees.	Infested fruit on ground.	Infested fruit at gathering.	Larvæ found in fruit from trees.	Larvæ in fruit on ground.	Larvæ in fruit at gathering.	Larvæ found in bands.	Cost of picking infested fruit and examination of bands.
1882.								
July 10, 12	211			60				$1.50
July 18							147	.60
July 20, 21	79			38				3.00
July 24							48	.60
July 31							46	.60
August 7, 9	119			35			26	3.50
August 12							14	.60
August 19, 21	100			63			27	2.60
August 28, 30	180			139			87	4.50
September 6, 9	481			308			498	5.30
September 15, 16	379			154			825	3.60
September 24							432	.60
September 26, 27	280			31				3.00
September 30							292	.60
October 14							94	.60
October 21							15	.60
October 28							1	.60
September 4		203			88			1.00
September 9		88			42			.50
September 15		60			22			.50
September 19		126			34			1.00
September 26, 27		36			4			
October 10		262						
October 21		255			55			.75
September 13			44			26		
October 10			156			28		
Total	1,829	1,030	200	838	195	54	2,552	36.90

Total infested fruit discovered, 3,059; total found, 3,639; total cost, $36.90.

Spraying the trees with arsenical mixtures.—January 22, 1879, Mr. J. S. Woodward, of Lockport, N. Y., at the meeting of the Western New York Horticultural Society, held in Rochester, stated that, having sprayed certain of his apple trees with Paris green quite early in the season, just after the fruit had formed, to destroy the Canker-worm,* the trees thus treated bore perfectly sound fruit, whereas the rest of the orchard was badly infested by the Codling Moth (see Rural New Yorker, February 8, 1879).

This important statement was not further verified until the spring of 1880, when Prof. A. J. Cook, of Lansing, Mich., sprayed some Siberian crab-apple trees on the 25th of May, and again on the 20th of June, with London purple, 1 tablespoonful of the poison (London purple) to 2 gallons of water. The results, as published in the Proceedings of the American Association for the Advancement of Science for 1880, page 669, published in 1881, were admirable, and it was stated to be a perfect remedy, although no tabulated statements were given. Since 1880 Professor Cook has made many experiments with both Paris green and London purple, and does not hesitate to recommend spraying with either as almost a panacea. He recommends their use in the proportion of 1 pound of the poison to 100 gallons of water.

The remedy was at first received with some disfavor on account of the supposed danger in its use. The objections were summarized by Professor Riley in the Farmer's Review, during the fall of 1880, and in the American Entomologist for October, 1880 (Vol. III, No. 10, p. 244), but in these very articles he indicated his appreciation of the remedy, if it could be divorced from its seeming dangers. Later experience in fact has shown that where properly used the remedy is not at all dangerous. Analyses made of the calyces of a number of poisoned apples by Professor Kedzie at Professor Cook's request, in 1880, indicated this fact. A striking note, however, is published by Professor Forbes, to the effect that apples taken September 10 from a tree sprayed September 3, and analyzed by Professor McMurtrie, each yielded .9 milligram of arsensic, "an amount such that 74 apples would convey a poisonous dose." This would indicate that fall poisoning possesses some danger on account of the cumulative effects of arsenic.

Professor Cook has since published many articles on this subject, and seems to have met with the most perfect success in the application of this remedy. His perfect results and his broad and sweeping statements are not, however, perfectly borne out by the results obtained by other experimentors. For instance, compare the following statement made by Professor Cook in 1886 with the results obtained in Ohio, Illinois, and California, and which are described in the following pages, and it will be seen that while he deserves every credit for the part which he has taken in putting this truly valuable remedy before the public, he is probably not justified in giving the impression that it is an absolute specific, or that he was the first to demonstrate its value for the purpose:

"It will be remembered that six years ago at the Boston meeting of the Science Association, I demonstrated the value of the arsenites, Paris green and London purple, as specifics against the Codling Moth

*The first suggestion of Paris green for the Canker-worm, so far as we can learn, was made by Dr. LeBaron, in his Second Illinois Report, 1872 (for 1871), p. 116. The suggestion was adopted in Illinois as early as 1873, and the poison was used with good success (see Riley in Third Report U. S. Ent. Com., p. 192).—L. O. H.

(*Carpocapsa pomonella*, Linn.). Experiments each year since confirm all that was then said. It is a matter of surprise that one early application of these arsenites should be so effective, when we remember the natural history of the insect. But in this case, as ever, facts are too strong for theory, as I have shown for years. One application of the poison made in May, before the apples are larger than peas, in fact, almost as soon as the blossoms have well fallen, is often all-sufficient. This year I have two crab-apple trees adjacent. One was treated, the other not. Frequent and careful investigation has failed to find an affected apple in the one case, while in the other a large proportion of the fruit is destroyed.

"Two points should be urged regarding this remedy: (1) Do not delay the application till June, when the larvæ are far into the fruit, out of harm's way. Neglect of this caution explains why some even of our careful investigators have partially failed. The remedy should be applied just when it will also destroy the destructive leaf-rollers and the dreaded canker-worms. (2) We must use a weak mixture. One pound of the poison to 100 gallons of water is best; then we can make thorough work without injury to our trees. With a pound to even 50 gallons of water we are quite likely to destroy some of the foliage if we make a thorough application." (A. J. Cook, Proc. 7th Ann. Meeting Soc. Prom. Agr. Sci., Buffalo, N. Y., 1886.)

It is but fair to state that in the Illinois experiments by Forbes, now to be treated, the first recommendation urged by Cook, viz, that the application be not deferred until June, was not followed and the first application was made June 9, although the season was probably a late one, as Forbes states that when the spraying with Paris green was begun the apples were only as large as currants. It should also be stated that Forbes' Paris green solution was stronger than Cook's London purple solution, the former using 1½ ounces to 5 gallons water, and the latter 1 pound to 100 gallons,* with the result that in Forbes' experiments considerable damage was done to the foliage. Moreover, Forbes' experiments with London purple were not begun until June 13, four days after his first Paris green application, and his mixture was only a little more than two-thirds the strength of the Paris green solution, which, by the way, made it slightly weaker than the solution recommended by Cook. These facts, therefore, render his conclusions as to the value of London purple of little weight, while his conclusions concerning Paris green should be accepted only with the understanding that he injured the foliage by the strength of his mixture. Forbes' conclusions from his 1885 experiments are as follows:

"(2) Owing to the scarcity of apples and the abundance of apple insects, the season was the most unfavorable possible for the success of these remedies.

"(3) The insecticides were applied suspended in water, the Paris green in the ratio of 1½ ounces to 5 gallons, the London purple in half that weight.

* * * * * * *

"(4) The spraying with Paris green began when the apples were about as large as currants, and four days later with the London purple.

* * * * * * *

*The London purple used by Forbes contained 22.5 per cent. metallic arsenic and the Paris green 15.4 per cent.

"(5) All the trees were thoroughly sprayed seven and eight times between June 9 and September 3.

"(6) The fallen apples were gathered six times from July 16 onward, and those remaining were picked as they ripened.

"(7) All the apples, both fallen and ripened, 16,529 in number, were examined individually for insect injuries, and those due to the Codling Moth and Curculios were separately noted.

"(8) As a result of the examination of 2,418 apples from trees which had been sprayed with Paris green, and of 2,964 others from check trees which had not been so treated, it appeared at the end of the season that 21 per cent. of the poisoned apples had been infested by the Codling Moth and 67.8 of those not so treated; while 27.3 per cent. of the poisoned lot had been infested by the Curculios and 51.3 per cent. of those not sprayed. That is to say, treatment with Paris green had saved something more than two-thirds of the apples which would otherwise have been damaged by the Codling Moth, and something more than half of those which would have been sacrificed to the Curculio. It should be remembered in this connection that the Paris green not only serves to protect the apples from attack, but by actually destroying the insects must assist to lessen the amount of insect injury in succeeding years. Analysis of apples one week after treatment with Paris green, a heavy storm intervening, gave abundant evidence that this insecticide could not be safely applied for some weeks preceding the harvesting of the fruit.

"(9) As a result of the comparison of 1,205 apples from a single tree sprayed with London purple, and 2,036 apples from a check tree not so treated, it appeared that 49 per cent. of the former were affected by the Codling Moth and 58.8 of the latter, and also that 39 per cent. of the first lot of apples had been invaded by Curculios and 48 per cent. of the second lot. The London purple thus saved about one-sixth of the apples which would otherwise have been sacrificed to the Codling Moth and about one-fifth of those otherwise to be spoiled by the Curculios.

"In comparing these results with those derived from the Paris-green experiment it must be remembered, however, that the spraying with London purple began four days later than that with Paris green, and that the latter, as used, contained about one-third more arsenic than the former. It should be further noted that both were applied to the limit of considerable damage to the foliage conspicuous as early as the last of July.*

*   *   *   *   *   *   *

"(11) As bands or traps serve only to capture the apple worm after it has done its mischief, and hence only interpose a general protection against future attack, and are moreover liable to be rendered ineffectual by neglect of one's neighbors, the use of Paris green will serve at least as a valuable addition to remedial measures against the Codling Moth. Since it may be safely applied, however, only

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* Elsewhere (p. 37) in the same article, however, Professor Forbes says: "Late in the season some scorching of the leaves similar to that attributed to the Paris green was noticed on this London-purple tree; less serious, however, than in the other case." In addition to this modification of the statement, we may call attention to the fact that there was a considerable reduction in the time elapsing between the first and second applications of the purple, as compared with the first and second applications of the green, and this will have considerable weight in accounting for the scorching by what Cook recommends as a safe mixture.—L. O. H.

for the spring brood, it is best to use both bands and insecticides, each measure supplying the deficiencies of the other.

"(12) Attending only to the picked apples, and condensing our statement of results to the last extreme, we may say that, under the most favorable circumstances, Paris green will save to ripening, at a probable expense of 10 cents per tree, seven-tenths of the apples which must otherwise be conceded to the Codling Moth; that London purple will apparently save about one-fifth of them; and that lime will save none."

Professor Forbes' tables follow upon the ensuing pages.

During the season of 1885 Mr. E. S. Goff, the horticulturist of the New York agricultural experiment station at Geneva, sprayed 6 trees three times with a solution of 1 ounce of Paris green to 10 ounces of water. The applications were made on June 3, June 5, and June 17. A heavy rain upon June 5 probably destroyed the effect of the first application. A careful examination in August and October of over 9,000 apples from the 6 trees sprayed and from 4 unsprayed check trees indicated that the average per cent. of wormy fruit from the sprayed trees was 13⅓, while the average per cent. of wormy fruit from trees not sprayed was 35¼. His conclusion is that the percentage of wormy fruit from the trees sprayed with Paris green and water was about 22 per cent. less than from those not sprayed. In other words, at this rate 100 barrels of apples picked from the sprayed trees would have yielded 22 barrels more fruit free from worms than the same number from the unsprayed trees (see Fourth Annual Report of the New York Agricultural Experiment Station, Albany, 1886, pages 246 to 248).

Professor Forbes, in Bulletin No. 1, office of the State entomologist of Illinois, gives a record of experiments made in 1886 supplementary to those recorded in the following tables. He sums up his conclusions in the following words:

"The experiments above described seem to me to prove that at least 70 per cent. of the loss commonly suffered by the fruit-grower from the ravages of the codling moth or apple-worm may be prevented at a nominal expense, or, practically, in the long run, at no expense at all, by thoroughly applying Paris green in a spray with water once or twice in early spring, as soon as the fruit is fairly set, and not so late as the time when the growing apple turns downward on the stem."

Paris-green experiment 1.

[Trees 1, poisoned, and 2, check.]

Trees.	Fruit.	Sprayed.	Examined.	Total No. of apples.	Codling Moth.		Curculios.		Both.	Total insects.		Undetermined injuries.		Total injuries.		Uninjured.	
					No.	*P. ct.*	*No.*	*P. ct.*		*No.*	*P. ct.*	*No.*	*P. ct.*	*No.*	*P. ct.*	*No.*	*P. ct.*
1	Fallen	June 9, 20, 30	July 16	141	10	7.1	28	21.3	(*)	38	27.0	10	9.7	48	34.0	93	66.0
2	...do	...do	...do	244	130	53.2	12	10.5	(*)	142	58.2	35	34.3	177	72.5	67	27.5
1	...do	July 15	July 24	177	42	23.1	12	9.5	(*)	54	30.4	1	.8	55	30.5	122	68.9
2	...do	...do	...do	370	253	68.4	66	56.4	(*)	319	85.4	4	7.8	323	85.5	47	13.0
1	...do	July 30	July 31	56	8	14.3	12	25.0	(*)	20	36.3	1	2.7	21	38.1	35	63.6
2	...do	...do	...do	120	84	70.0	23	63.8	(*)	107	89.0	.....	.....	107	89.0	13	10.8
1	...do	August 5	August 7	93	20	21.5	27	36.9	(*)	47	50.5	4	8.7	51	54.8	42	45.1
2	...do	...do	...do	61	34	55.7	19	70.3	(*)	53	86.8	2	25.0	55	90.1	6	9.8
1	...do	August 27	August 27	168	57	33.9	48	43.2	(*)	105	62.5	2	3.1	107	63.6	61	36.3
2	...do	...do	...do	189	133	70.3	42	75.0	(*)	175	92.5	4	28.0	179	94.7	10	5.2
1	...do	September 3	September 3	30	14	46.6	3	18.9	(*)	17	56.6	3	23.0	20	66.6	10	33.3
2	...do	...do	...do	53	42	79.2	8	72.7	(*)	50	94.3	.....	.....	50	94.3	3	5.6
Total 1	...do			665	151	22.7	130	25.2	(*)	281	42.2	21	5.4	302	45.4	363	54.5
Total 2	...do			1,037	676	65.1	170	47.0	(*)	846	82.3	45	23.6	891	86.7	146	14.0
1	Picked	September 3	September 10	846	178	21.1	230	34.4	(*)	408	49.2	184	42.0	592	69.9	254	30.0
2	...do	...do	...do	783	591	75.4	147	76.5	(*)	738	94.2	19	42.2	757	96.6	26	33.0
Grand total 1				1,511	329	21.7	360	30.4	(*)	689	45.6	205	25.2	894	58.0	617	40.8
Grand total 2				1,820	1,267	69.6	317	57.3	(*)	1,584	87.0	64	27.1	1,648	90.5	172	9.4

Paris-green experiment 2.

[Trees 3, poisoned, and 4, check.]

Trees.	Fruit.	Sprayed.	Examined.	Total No. of apples.	Codling Moth No.	Codling Moth P. ct.	Curculios No.	Curculios P. ct.	Both.	Total insects No.	Total insects P. ct.	Undetermined injuries No.	Undetermined injuries P. ct.	Total injuries No.	Total injuries P. ct.	Uninjured No.	Uninjured P. ct.
3	Fallen	June 13, 20, 30	July 16	73	6	8.2	11	16.4	(*)	17	23.2	10	17.8	27	36.9	46	63.0
4	...do	...do	...do	326	205	62.8	56	46.2	(*)	261	80.0	8	12.3	269	82.5	57	17.4
3	...do	July 15	July 24	114	31	27.2	15	18.0	(*)	46	40.3	.....	.....	46	40.3	68	59.6
4	...do	...do	...do	149	79	53.0	37	52.8	(*)	116	77.8	.....	.....	116	77.8	33	22.1
3	...do	July 30	July 31	74	9	12.1	17	26.1	(*)	26	35.1	.....	.....	26	35.1	48	64.8
4	...do	...do	...do	112	51	45.5	41	67.2	(*)	92	82.1	.....	.....	92	82.1	20	17.8
3	...do	August 5	August 7	48	7	14.5	8	19.5	(*)	15	31.2	1	3.0	16	33.3	32	66.6
4	...do	...do	...do	56	30	53.5	19	73.0	(*)	49	87.5	.....	.....	49	87.5	7	12.6
3	...do	August 27	August 27	267	52	19.4	56	26.0	(*)	108	40.4	7	4.4	115	43.0	152	56.9
4	...do	...do	...do	144	129	89.5	13	86.6	(*)	142	98.5	.....	.....	142	98.5	2	1.4

* Not separately reported.

Paris-green experiment 2—Continued.

Trees.	Fruit.	Sprayed.	Examined.	Total No. of apples.	Codling Moth.		Curculios.		Both.	Total insects.		Undetermined injuries.		Total injuries.		Uninjured.	
					No.	*P. ct.*	*No.*	*P. ct.*		*No.*	*P. ct.*	*No.*	*P. ct.*	*No.*	*P. ct.*	*No.*	*P. ct.*
3	Fallen	September 3	September 3	31	9	28.9	5	22.7	(*)	14	45.1	.....	.....	14	45.1	17	54.8
4	do	do	do	35	31	88.5	2	50.0	(*)	33	94.2	.....	.....	33	94.2	2	5.7
Total 3	do			607	114	18.7	112	22.6	(*)	226	37.2	18	4.7	244	40.1	363	59.8
Total 4	do			822	525	63.6	163	56.5	(*)	693	84.3	8	6.2	701	85.2	121	14.7
3	Picked	September 3	September 10	301	66	21.9	70	23.2	11	125	41.1	13	10.2	143	47.5	158	52.4
4	do	do	do	322	220	68.3	117	36.3	56	281	87.3	13	31.9	350	93.8	28	8.7
Grand total 3				908	180	19.8	182	22.9	11	351	39.8	36	6.4	387	42.5	521	57.3
Grand total 4				1,144	745	65.1	285	42.8	56	994	85.1	21	14.0	1,051	86.9	149	13.0
Grand total 1 and 3				2,418	509	21.0	542	27.3	11	1,042	43.9	241	17.6	1,280	52.9	1,138	47.0
Grand total 2 and 4				2,964	2,012	67.8	602	51.3	56	2,558	86.2	85	20.9	2,643	89.2	321	10.8

London-purple experiment.

[Trees 5, poisoned, and 6, check.]

Trees.	Fruit.	Sprayed.	Examined.	Total No. of apples.	Codling Moth No.	Codling Moth P. ct.	Curculios No.	Curculios P. ct.	Both.	Total insects No.	Total insects P. ct.	Undetermined injuries No.	Undetermined injuries P. ct.	Total injuries No.	Total injuries P. ct.	Uninjured No.	Uninjured P. ct.
5	Fallen	June 13, 20, 30	July 16	444	154	34.6	104	35.8	(*)	258	58.1	11	5.9	269	60.6	175	39.1
6	do	do	do	927	486	52.4	197	44.6	(*)	683	73.5	2	.8	685	73.7	242	26.1
5	do	July 15	July 24	165	82	49.6	34	40.9	(*)	116	70.3	2	4.0	118	71.5	47	28.4
6	do	do	do	366	165	45.0	90	44.7	(*)	255	69.6	1	.9	256	69.9	110	30.0
5	do	July 30	July 31	88	35	39.7	36	67.9	(*)	71	80.6	.....	.....	71	80.6	17	19.3
6	do	do	do	146	73	50.0	60	82.1	(*)	133	92.5	.....	.....	133	92.5	13	9.0
5	do	August 5	August 7	68	27	39.7	33	80.4	(*)	60	88.2	.....	.....	60	88.2	8	11.5
6	do	do	do	84	47	55.9	35	94.5	(*)	82	97.6	.....	.....	82	97.6	2	2.3
5	do	August 27	August 27	243	171	70.3	20	28.0	(*)	191	78.6	.....	.....	191	78.6	52	21.4
6	do	do	do	243	207	85.1	21	58.3	(*)	228	93.4	2	13.3	230	94.6	13	5.3
5	do	September 3	September 3	40	26	65.0	3	21.4	(*)	29	72.5	1	9.0	30	75.0	10	25.0
6	do	do	do	62	62	100.0	.....	.....	(*)	62	100.0	.....	.....	62	10.0	.....	.....
Total 5	do			1,048	495	47.2	230	41.6	(*)	725	69.1	14	4.6	739	70.1	309	29.5
Total 6	do			1,828	1,040	56.8	403	51.1	(*)	1,443	78.8	5	1.3	1,448	79.0	380	20.8
5	Picked	September 3	October 9	157	96	61.1	48	30.5	25	119	75.1	2	5.2	121	76.3	36	22.9
6	do	do	do	208	158	75.9	79	37.9	54	183	87.9	6	2.4	189	90.8	19	9.1
Grand total 5				1,205	591	49.0	278	39.1	25	844	70.0	16	4.2	860	71.3	345	28.6
Grand total 6				2,036	1,198	58.8	482	48.3	54	1,626	79.7	11	2.9	1,637	80.4	399	19.6

* Not separately reported.

What with the general experience among practical apple-growers who had used them, and Prof. Cook's experiments, Prof. Riley had come to accept the safety and general efficacy of the arsenites, properly used, as preventive of apple worm attack, and, in fact, had in consequence suggested their probable value, properly used, as against Curculio attack, in his address before the American Horticultural Society at New Orleans in 1885. With a view of testing this point and of settling some others raised by Forbes' work, Professor Riley had planned an extensive series of experiments to be made, during the season of 1887, and he instructed our Ohio agent, Mr. Alwood, who was advantageously located on the grounds of the Ohio Experiment Station, at the beginning of the season to work in this direction. Unfortunately, however, the season proved unpropitious, nearly all the apples in the neighborhood "blighting" after setting, although they set very full, and Mr. Alwood was called away in early July to take part in another and more pressing investigation. We quote from Mr. Alwood's notes such passages as bear upon the experiments made:

"On May 17, when first spraying was done, the bloom had fallen and an abundance of fruit was set on the young trees. However, within a few days fully 75 per cent. of this blighted, except in a few instances. These instances were trees sprayed, and as the observations given will show, there was scarcely fruit enough in the orchard, outside of trees treated, to furnish material to compare with treated trees.

"The orchard is composed of about 130 trees just coming into bearing. Twelve of the best trees were selected for the work, thinking there was abundant material around them for comparison. Six were sprayed with London purple and six with Paris green, at the rate of 1 pound of poison to 50 gallons of water. They were sprayed twice—May 17 and June 13. At first spraying Curculios were already at work, and it did not seem that spraying stopped them. The Codling Moth had not yet been noticed, and their larvæ did not put in appearance until after June 1.

"On June 21 the fallen fruit was collected and examined for larvæ. At this date trees untreated were almost barren of fruit, it having fallen before attaining any size or larvæ were hatched.

"Fallen fruit, Paris green.....	Curculio larvæ, 213 apples. Codling Moth larvæ, 13 apples.
"Fallen fruit, London purple..	Curculio larvæ, 267 apples. Codling Moth larvæ, 9 apples.
"Fallen fruit, untreated	Curculio larvæ, 96 apples. Codling Moth larvæ, 42 apples.

"The small amount of fallen fruit has already been explained. Before the close of season there was scarcely an apple on unsprayed trees, while some of those treated ripened several bushels. (They were all small trees.)

"Second counting was made June 28.

"Fallen fruit, Paris green.....	Curculio larvæ, 98 apples. Codling Moth larvæ, 10 apples
"Fallen fruit, London-purple..	Curculio larvæ, 87 apples. Codling Moth larvæ, 9 apples.
"Fallen fruit, untreated trees.	Curculio larvæ, 4 apples. Codling Moth larvæ, 18 apples.

"At this date both species were about full grown and some were leaving the fruit.

"In no instance did I find two Codling Moth larvæ in the same fruit, but several times found it and Curculio larvæ together, in which case I counted it to both; several times found as many as six Curculio larvæ in same fruit.

"I had also planned a much more extensive set of experiments for the old orchard, but it set no fruit at all.

"I sprayed two orchards for farmers who were interested, one living 6 and the other 9 miles out in the country. These were so far out that close observations were impossible. I went to Mr. F. P. Dill's place, 9 miles out, on Saturday, May 14. The trees were but a few days past bloom and in fairly healthy condition. The Canker-worms which have infested this orchard for some years had already made their appearance in such numbers that they would soon have destroyed the foliage on fully one-half the trees. The orchard is an old one, part of the trees having been planted by one of the first settlers, and some of them are 30 to 40 feet high and 40 to 50 feet through the branches at the widest part. It contained about 250 trees. The spray apparatus used was the Nixon's Little Giant, with his small-size pump fitted with but one spray nozzle.

"On the first half of the orchard we used Paris green and on the other London purple, both mixed 1 pound to 75 gallons of water.

"Three men did the work, which allowed a change at the pump at frequent intervals, as the force required with this size pump to spray such large trees was more than one man could stand for any length of time. However, by changing about, the work was readily accomplished. The whole time occupied was a little over eight hours. Six pounds poison was used and 450 gallons of water.

"*Results.* Here, as at the university, the fruit nearly all blighted.

"The Canker-worms were destroyed, and what little fruit matured was quite free from Codling Moth.

"The other orchard sprayed was for A. J. Gantz, 6 miles out in the country.

"His is an old orchard containing about 200 trees; used London purple and Paris green as before.

"This orchard was fairly sprinkled with Canker-worms, both *pometaria* and *vernata* being present.

"The worms were destroyed and the trees made a good healthy season's growth, better than for years. The fruit was just setting at time of application and the trees matured about one-half crop, not blighting so badly as the others. I examined these several times and found only from 20 to 30 per cent. affected by Codling Moth, and the farmer said it was some of the best fruit he had grown for years.

"The largest orchard in the county is on an adjoining farm owned by Mr. Coe, and his fruit that did mature was almost worthless from effect of Codling Moth."

Mr. Alwood sent material to five different prominent growers throughout the State of Ohio, asking them to make experiments, but only one furnished a detailed report.

Mr. Alwood vouches for Mr. Cushman's reliability and states that he is a member of the American Pomological Society, American Horticultural Society, and Ohio Horticultural Society, and his report is so interesting that we publish it in full:

EUCLID, OHIO, *November* 14, 1887.

SIR: It gives me pleasure to make the following report concerning the use of Paris green and London purple for the Codling-moth worm in apples.

Spraying apparatus used was the Little Gem, manufactured by A. H. Nixon, Dayton, Ohio. Have had but little experience with atomizers, but think this one is very satisfactory. Eighteen apple trees were selected for the experiments. The trees are twenty years old, have borne for several years, and but few perfect specimens have ever been produced. The trees are vigorous, having a spread of 30 feet. Varieties are Baldwin, King of Tompkins County, and Talman.

On the 22d of May the first application was made. This was exactly one week from full bloom. The Baldwins were one-fourth inch in diameter.

The proportion of green and purple had been previously carefully weighed, so that I could mix them in the following strengths: 1 pound to 100 gallons, 1 pound to 75 gallons, and 1 pound to 50 gallons.

The tank and pump were placed on a wheelbarrow for convenience in moving. Ten feet of hose was used. The nozzle end was tied to the end of a pole for the purpose of carrying it into and over the trees. Father managed the hose while I worked the pump. It took about $2\frac{1}{2}$ gallons per tree and about five minutes to apply it.

The day was clear and a light breeze served to carry the mist through the trees. It settled on apples and leaves like a heavy dew. The following plot of trees will show the detail of the experiment:

Variety.	Paris green.		London purple.	
	First row.	Proportion.	Second row.	Proportion.
Baldwin	x1 x2 x3	1 lb. to 100 gals.	x x x	1 lb. to 100 gals.
King	x4 x5 x6	1 lb. to 75 gals.	x x x	1 lb. to 75 gals.
Talman	x7 x8 x9	1 lb. to 50 gals.	x x x	1 lb. to 50 gals.

First application May 22, seven days from full bloom; second application May 26.

The afternoon after the first application two light showers fell; on the evening of the 24th two more; one was quite heavy. These showers coming so soon after spraying made me fear they had washed out the poisons. On the 25th I found little mites of maggots, from one to three in each calyx. After this they seemed to grow less, until scarcely any could be found on the 4th of June. One tree was not sprayed and one only the first time. These are not included in the eighteen.

Tree not treated dropped all of its fruit, and I did not find one apple but what was wormy. The tree sprayed only once had a fair share of perfect fruit, but not as much as those receiving two doses.

The fruit from the eighteen trees, as near as we could judge, was about alike. Trees 1, 2, 3, receiving the weakest application, had as large a proportion of fair apples as 7, 8, 9, which received the strongest. No difference could be distinguished between the amount of fair fruit on the Paris-green row and that on the London-purple row. About three-quarters of the apples were free from worms.

The practical result of the spraying is about as follows:

40 bushels marketable apples, at 80 cents	$32.00
Poisons and their application	4.00
	28.00
Probable result if not sprayed, 40 bushels cider apples, at 15 cents	6.00

Very truly,

E. H. CUSHMAN.

Mr. W. B. ALWOOD,
Special Agent, Division of Entomology.

It is only recently that the arsenical poisons have been seriously considered in California, but during the summer of 1887 a number of experiments were made at Berkeley by Messrs. Wickson and Klee, and the results, as summarized in tabular form in Bulletin No. 78 of the Agricultural Experiment Station, University of California, we give below.

It will be noticed that very weak solutions of Paris green were used, the strongest being more than twice as weak as the solution used by Professor Forbes. The gain of 71 per cent. in sound apples, however, with no apparent damage to the foliage, must be considered as quite satisfactory, although all of the experiments were made upon too small a scale to furnish a basis for reliable deductions. A

peculiar feature of the test is that the stronger substance (London purple) is used in much smaller dilution than the weaker substance (Paris green), and it is a very strange result that the purple used in the proportion of 1 pound to 160 gallons water should badly injure the foliage in the case of the two varieties of pear experimented with, and slightly damage the apples, while in Michigan 1 pound to 100 gallons is recommended as perfectly safe for apples. The California varieties may have been peculiarly susceptible, or the climatic conditions of moisture and evaporation such as to render the trees more liable to damage than in Michigan. We can not find that Professor Cook indicates the proper time of day for spraying, but we have found in Washington that spraying on a warm, dry, sunshiny day will be more apt to produce injurious results than the opposite, or, in other words, the more rapid the dehydration the greater the effect upon the foliage. Professor Riley has also shown (see Bulletin 10, Div. of Ent., p. 13) that after each rain the poison takes a new effect upon the foliage, and the inference is plain that in a climate where the dews at night are heavy and the days dry and warm the effect of the poison will be greater. Moreover, the foliage is more rapid of growth and consequently tenderer in California than in our Northeastern States.

The white arsenic experiments recorded in the following tables are practically valueless on account of the small scale upon which they were tried. The inference is, as Mr. Wickson points out, that the worms were not on hand to be killed in the case where the stronger solution shows a percentage of loss while the weaker shows a percentage of gain.

Paris green (1 *pound to* 160 *gallons of water*).

Fruit.	Variety.	Date of application.	Apparent effects.	Worms in fruit and under bands.	
				On treated tree.	On untreated tree.
Pear	Nouveau Poiteau	May 3 and 19	None	10	23
Pear	Nantais	May 3 and 19 and once later.	...do	4	4
Apple	Red Canada	May 3, 19, and June 1.	...do	4	35
Total				18	62
Gain, per cent				71	

Paris green (1 *pound to* 320 *gallons of water*).

Fruit.	Variety.	Date of application.	Apparent effects.	On treated tree.	On untreated tree.
Pear	Duchesse Précoce	May 3	None	3	8
Pear	Dr. Reeder	May 3 and 19	...do	1	27
Pear	Chaptal	May 3, 19, and June 1.	...do	6	1
Apple	Duchess Oldenburg	May 3 and 19	...do	0	1
Apple	Fameuse	May 3, 19, and June 1.	...do	9	4
Total				19	41
Gain, per cent				54	

Paris green (1 *pound to* 160 *gallons of water, with* 2 *pounds of soap*).

Fruit.	Variety.	Date of application.	Apparent effects.	On treated tree.	On untreated tree.
Pear	Beurre Gris d'hiver	May 3 and 19*	None	5	2
Apple	Wells' Sweet	May 3	...do	3	3
Apple	Duchesse Mignonne	May 3 and 19	...do	1	13
Total				9	18
Gain, per cent				50	

* Considerable settling in can.

London purple (1 pound to 160 gallons of water).

Fruit.	Variety.	Date of application.	Apparent effects.	Worms in fruit and under bands. On treated tree.	Worms in fruit and under bands. On un-treated tree.
Pear	De Tongres *	May 3	Badly injured	13	21
Pear	St. Michael Archangel	...do	...do	4	0
Apple	Disharoon	May 3, 19, and June 1	Little damage	9	9
Apple	Yopps' Favorite	May 3, 19, and June 1†	...do	5	7
Total				31	37
Gain, per cent				16⅔	

London purple (1 pound to 80 gallons of water).

Fruit.	Variety.	Date of application.	Apparent effects.	On treated tree.	On un-treated tree.
Pear	Emile de Heyst	May 3, 17,† and June 1†	Fruit and foliage damaged.	19	6
Pear	Madam Treyve	May 3 and 18†	...do	0	24
Pear	Augustus Dana	May 3	...do	0	4
Apple	Seek no Further	May 3	Badly injured	16	51
Total				35	85
Gain, per cent				59	

White arsenic (1 pound to 320 gallons of hot water).

Fruit.	Variety.	Date of application.	Apparent effects.	On treated tree.	On un-treated tree.
Pear	Callebasse Monstreuse	May 3	Foliage little damaged.	4	3
Apple	Grimes' Golden Pippin	May 3 and 19		1	0

White arsenic (1 pound to 480 gallons of water).

Fruit.	Variety.	Date of application.	Apparent effects.	On treated tree.	On un-treated tree.
Pear	Ott	May 3	None	0	1
Apple	Early Joe	...do	...do	0	17

White arsenic (1 pound to 640 gallons of water, with soap).

Fruit.	Variety.	Date of application.	Apparent effects.	On treated tree.	On un-treated tree.
Pear	Napoleon	May 3, 20, and June 1	None	1	3
Apple	Hall	May 3, 19, and June 1	...do	0	(‡)

* Two and one-half gallons of wash used.
† Strength of second and third sprayings, 1 pound to 220 gallons water.
‡ No check.

In the Transactions of the Iowa Horticultural Society for 1882 (vol. 17) is printed a prize essay by Hon. J. N. Dixon, of Oskaloosa, who strongly recommends the use of a solution of white arsenic, 1 pound to 200 gallons of water, for the Codling Moth, Tent Caterpillar, the Canker-worm, and the Apple Bucculatrix. He states (inferentially) that he first applied this remedy in 1875, intending it only for Canker-worms, thus arriving at the result in the same way as did Mr. Woodward in 1878. The paper, as a whole, contains many errors and is not of great value, and we mention it simply as a matter of record. It will be noticed by comparison that in the California white arsenic experiments the foliage was slightly damaged with a solution of 1 pound of this substance to 320 gallons of water.

In a discussion printed in the Transactions of the Iowa Horticultural Society, 1876, p. 52, Mr. Dixon mentioned the fact that he tried

Paris green for the Canker-worm in 1875, and at the advice of John Smith, of Des Moines, who had tried it previously, he experimented successfully with white arsenic in 1876.

It was probably this application, according to his 1883 statement, which put him on the track of the efficacy of the arsenical mixture for the Codling Moth, but we have no contemporaneous printed evidence that he made this inference, though there is correspondence with Professor Riley that may throw light upon the matter when fully studied.

It may be gathered from what precedes that as yet the use of arsenical mixtures for the Codling Moth is in its infancy. In limited localities practical apple-growers are taking it up, and particularly during the season of 1887 we have seen communications in the agricultural and horticultural journals giving accounts of successful trials. These, however, have been almost entirely in New York, Ohio, Michigan, and Illinois. It has been proven to be the best remedy yet known, but further experiments are still needed to ascertain the best modifications of proportions according to climate, condition of weather, and time of day.

Apparatus for applying the arsenical Mixtures.—The question of a suitable apparatus for spraying one's fruit trees is an important one, but is not difficult of solution. Good results can be obtained with the simplest apparatus. Professor Riley, in his different publications, has repeatedly described pumps and appliances which will answer this purpose admirably. It is not a difficult matter to mount a strong double-acting force-pump firmly upon a tight barrel, to mount the latter upon a sled or cart, to attach the rubber hose to an extension pole, and to fasten a nozzle at tip; and yet, having done this, a serviceable apparatus is complete, and at small cost beyond the price of the pump. Such an apparatus was described in its minutest details and figured in all its parts in the report of the Entomologist, annual report of this Department for 1881–'82, again in the report for 1883, and again in Bulletin No. 10 of the Division of Entomology. In the fourth report of the U. S. Entomological Commission a large series of pumps available for this purpose is figured and described. The subject of nozzles is there taken up, as also in the other publications just mentioned. A very complete, if somewhat cumbersome, apparatus is figured at Plate V, Rep. Ent. U. S. Dept. Agr. for 1886. It is one which is in use in California for spraying orange orchards for the Fluted or Cottony Cushion-scale. Its special features are its large size, the pump supplying two extension poles, the hose-reel, and the portable ladders.

Several pumps, with all accessory apparatus adapted for just this kind of work, have recently been placed on the market. Messrs. Woodin & Little, of 509 Market street, San Francisco, have mounted a strong double-acting pump with air chamber and brass valves, manufactured in New York by the Goulds, upon a 30-gallon barrel, with sled, nozzles, bamboo extension pole, mixer, strainer, and hose, and sell the apparatus complete for from $30 to $35, according to the amount of hose needed. This outfit seems to be a good one, and it may be an economy for busy orchardists within easy reach of San Francisco to purchase it.

The second apparatus is that manufactured by A. H. Nixon, of Dayton, Ohio, and which is described on page 57 of Bulletin 10 of the Division of Entomology. It is made in three styles and sizes, varying in price from $15 to $55.

The Field Force Pump Company, of Lockport, N. Y., have also placed on sale a spraying outfit, consisting of a strong force-pump, 8 feet of discharge hose, spraying nozzle, couplings, and suction pipe, all ready to mount on a barrel. The price of this outfit is $10. They also have a spraying apparatus operated by horse-power.

SILK CULTURE—REPORT OF THE YEAR'S OPERATIONS.

MADE TO THE ENTOMOLOGIST.

By PHILIP WALKER, *Agent in charge.*

Plates VII and VIII.

DISTRIBUTION OF SILK-WORM EGGS.

The policy of the Department, set forth in the last annual report, to distribute only eggs of the large Milanese varieties, has been followed during the past year, and a supply of eggs of the same races has already been purchased for distribution the coming season. These eggs have, in general, given excellent results, many persons having produced at the rate of 120 pounds of fresh cocoons for each ounce of eggs put in incubation. The distribution of last year amounted to about 150 ounces of eggs, sent to about 360 applicants, inhabiting almost every State east of the Rocky Mountains. These eggs were distributed in quantities varying from one-quarter of an ounce to one ounce. A suitable hibernating box was constructed at the Department some two years ago, and in it we have been enabled to keep eggs up to the moment that silk-raisers were ready to begin the rearing, at which period the distributions usually take place.

With the Commissioner's authority and under your instructions I have visited the silk-fields of Europe during the summer, and among other establishments inspected the egg-producing stations of Signor Susani, in Italy, and M. Deydier, in France. A description of these institutions and their methods of work will prove of interest to silk-growers. The eggs from M. Deydier's establishment have been largely used in the United States and have given universal satisfaction.

EUROPEAN EGG-PRODUCERS.

After Pasteur made his discoveries, which resulted in the establishment of his system of microscopical selection in the production of Silk-worm eggs, Signor Susani, of Milan, was one of the first to put the process into operation on a commercial scale. He now has the largest establishment of this sort in the world, employing 3,000 hands during the coupling season and 750 for microscopical examination. His place is situated at Albiate, about 10 miles northeast of Milan, and is called the Cascina Pasteur. The building is about 100 feet wide by 120 feet long, the center of the ground floor being occupied by the hibernating room, which is so well described by Maillot* that his account of it is reproduced here:

This room is 20 meters long by 5 wide and 4 high; its walls are double, the exterior one being 70 centimeters and the interior one 15 centimeters thick; the floor is

* Leçons Sur le Ver à Soie du Murier, p. 30.

formed by a layer of rubble, covered with hydraulic cement; the walls and floor are covered with asphalt. The ceiling, made of iron and brick, is covered with a layer of sand, over which is a floor, which in turn is covered with a large quantity of sawdust. To this ceiling are suspended three long boxes of galvanized iron, in which there circulates a concentrated solution of chloride of magnesium, which only freezes at — 20° C. This liquid is cooled by suitable refrigerating machines, and is carried from them in pipes to the boxes of the hibernating room. The air contained in this room is dried by masses of quicklime placed in wooden boxes; this air is renewed through openings in the doors and windows, and they are also careful to open for an instant a little before sunrise the windows which give on the surrounding rooms.

The refrigerating machine is one employing sulphurous acid after Pictet's method. The receptacle in which the liquid sulphurous acid is gassified is entirely plunged into brine, which is consequently cooled as the apparatus operates. This cold brine is forced by means of a pump into the troughs on the ceiling. At the same time another pump takes the sulphurous gas and liquefies it in a second receptacle, from which it is made to run from time to time into the first.

To assure the regularity of temperature in the cold room two Pictet machines are used alternately and prevent the suspension of work in case of accident to one.

This arrangement enables Signor Susani to safely hibernate large quantities of eggs, which amount sometimes to more than 60,000 ounces per year, though the capacity of the chamber reaches 100,000 ounces.

On each side of the hibernating room are the rooms occupied by the microscopists and their helpers. The division of labor in the preparation and examination of moths has here been carried to great perfection, the cells containing the eggs passing through the hands of three operatives before they reach the microscopist. The moths are carried to her already crushed in a small mortar, which occupies one compartment of a box, in the other division of which is placed the corresponding cell of eggs. Twenty of these boxes fill a tray, which serves to carry the stock through the different parts of the room while the moths are submitted to the various examinations. The microscopist then examines the twenty moths, one by one, placing tin tags bearing her number on the boxes of those which have shown corpuscles. The tray is then passed to the table of the "first comptroller."

At this table an attendant takes small portions of the liquids of each of the healthy moths and mixes them intimately in a small porcelain jar, the contents of which is examined by the comptroller. If he finds no traces of the pébrine after examining several slides from this lot, the jar containing the mixture is sent on to the second comptroller, who has portions of it mixed with like portions of the contents of several other jars, and submits the new mixture to another examination. If, on the other hand, the first comptroller has found disease in the mixture examined by him, the tray from which it was taken is sent back to the microscopist for further examination.

The cells passed by the second comptroller are then sent to a man who separates the pure eggs from the impure. In addition to the force of microscopists and their immediate helpers a large force of laborers, all girls and women, are occupied in the cleansing of the mortars and other apparatus used. The cells of unhealthy eggs are at once destroyed by fire, while those containing good ones are turned inside out and hung in the loft upon racks, under which sheets are laid to catch any eggs that may drop. The eggs are washed from the cloths later in the year when the microscopical work is terminated.

The advantages claimed for this system of "double control" are denied by many persons whose opinion on the matter is well worth consideration. Their objections to it are based on the following

reasoning: Suppose the extreme case of a tray containing twenty moths which have been pronounced healthy by the microscopist. If one of those moths were diseased it would be quite as possible as not to overlook the corpuscles which it contained in a mass of over a fluid ounce of the mixture, and once it is passed by the first comptroller the chance of its being discovered by the second is much smaller, as he takes but a small portion of the primary mixture and combines it with portions of others which might have been entirely healthy. Altogether they claim that the double control is but a step in an unworthy system of advertising.

At the Deydier establishment, which is situated at Aubenas, in the Department of the Ardêche, in France, this system of double control has been abandoned, the microscopists being divided into small groups, one operative supervising the accuracy of the work of the others of the group. The French establishment occupies an old filature building, and is not so completely fitted up as the Italian one. The production of eggs reaches about 15,000 ounces per annum. M. Deydier informed me that he had noticed that cocoons raised in the United States from his eggs were larger and better than those from which the eggs were originally produced in France. This, however, is not an unusual result of transplanting stock to a new climate.

MULBERRY TREES.

No effort has yet been made to rear Silk-worms on an extensive scale at the Department, because, though Osage Orange leaves may be easily obtained in any desired quantity, it has been impossible to find, in the immediate vicinity, a proper supply of Mulberry leaves with which to make comparative tests. A plantation, however, has been recently started in the Department grounds, which includes some of the best varieties, and it is hoped that we shall soon have a plentiful supply of food. Among other trees recently purchased are some from the Cattaneo nurseries, near Milan, where the care of the young trees is so systematic and well-conducted that an extended description of their methods will not be out of place here. Judging from our own experience it is not the custom of American nurserymen to in any way prune or train their Mulberry trees while in their plantation. As a result it is found to be almost impossible to train a two or three year old tree so that its foliage may be picked with the proper facility. The proper pruning and training of Mulberry trees is excessively important, as it is conceded upon all sides that three times as many leaves may be picked, in a given time, from a well-pruned tree as from one where nature has been allowed full sway. The methods employed in the Cattaneo nursery, while almost identical with those described in the tenth chapter of your manual on the Silk-worm, tend to show the care with which European nurserymen handle their stock from the seed up, so that a four-year-old tree, when sent from the nursery, is in just as good condition as if it had been raised on the silk-grower's own plantation.

THE CATTANEO NURSERIES.

The Cattaneo nurseries have their office in Milan and their plantations in the immediate vicinity. They make a specialty of a White Mulberry, which they call the "Primitive," the original stock of which they imported at great expense from China. It is, as far as can be

determined by casual examination, practically the same tree as the *japonica*, which has been largely planted in this country, and the advantages claimed for it are its rapid growth and large, nutritious leaves. The trees sold by the Cattaneo Company are all seedlings, and their manner of cultivation is as follows:

The seeds are planted in the month of June in little rills, and the first year they attain a height of about 2 feet. The spring of the second year they are transplanted and set out in quincunx, the rows being about 3 feet apart. The following spring they are cut down to the ground and one shoot only allowed to grow. This shoot attains a height of about 8 feet in one year, and has leaves as large as the two hands springing from its whole length. The fourth spring it is cut off to form the crown, at about 6 feet from the ground, and but three or four fine buds allowed to grow into branches, the rest of the stem being carefully kept free from suckers. The fifth spring it is ready for permanent planting and, in good ground, will furnish from 40 to 50 pounds of leaves the first year thereafter. Plate VII shows one of these trees eight years old from the seed and Plate VIII the same tree without its leaves. The tree from which these cuts were photographed was 26 feet high and 56 feet in circumference.

EXPERIMENTAL STATIONS.

It has been found necessary in European sericultural countries to constantly study the practical rearing of Silk-worms from a scientific point of view, so as to prevent the spread of false ideas and methods of work and eliminate such fallacies as may have found root in the minds of silk-growers. The Austrian Government first opened an experimental station for this purpose at Goritz, in 1870. The work of this station has been described in the report of the American minister at Vienna, which was printed in Vol. XII of the Consular Reports, page 262. The example thus set by Austria was soon followed by Italy in the establishment of a similar station at Padua, and by France, whose station is in connection with the University of Montpelier. All of these stations are in charge of men of great eminence in the science to which they have devoted their lives, Haberlandt being director of the Goritz station, Verson of that at Padua, and Maillot of the French institution. If the aims of the Department in establishing silk culture in the United States should be successful it will undoubtedly be necessary for our Government to follow the example thus set them in Europe, and it may therefore be of interest to publish an account of the station at Padua, as translated from a recent Italian work. It may be well to add that the Italian Government has also established upwards of sixty observatories in different parts of the Kingdom, which co-operate with the central station and become valuable means of collecting sericultural statistics, disseminating useful information, and aiding silk-raisers by the microscopical examination of eggs and other useful labors. Such observatories might ultimately be established in the United States in connection with the recently-organized agricultural experimental stations in the different States.

THE ROYAL SERICULTURAL EXPERIMENTAL STATION AT PADUA.

During the year 1870 the Austrian Government opened an experimental station at Goritz with a view to studying "the malady" of

the Silk-worm. Italy, where silk culture is one of the principal sources of wealth, was not long in following this example, and in the month of April, 1871, a royal decree established at Padua an institution called "The Experimental Sericultural Station." The Italian Government and the city and chamber of commerce of Padua pay the expenses of this institution. Its objects are:

(1) To study the raising of Silk-worms under the best conditions, and experiment with the products thereof.

(2) To study the feeding of Silk-worms both by means of physiological and chemical experiments.

(3) To study the causes of the diseases of Silk-worms and of the Mulberry.

(4) To produce and distribute healthy Silk-worm eggs and to examine eggs for silk-growers.

(5) To experiment with new varieties of eggs, as well as with all other articles which concern the magnanerie.

(6) To undertake all such studies and experiments as might be useful to sericulture.

(7) To distribute circulars and to deliver lectures so as to make generally known the best means of succeeding in silk culture.

(8) To give the greatest possible publicity to all matters connected with the sericultural industry in the Kingdom of Italy.

The governing body of the sericultural station consists of an administrative council, of which the director is a member, the members of the council hold office for three years, one-third of its membership going out of office each year.

The director is the chief of the institution, and his staff consists of a deputy and an assistant. It is their duty to do everything, either by study or by experiment, to advance the industry in the Kingdom.

Beside the building occupied by the station there is also a greenhouse for Mulberry trees, the leaves of which are employed in making advance educations, that is to say, educations before the usual season. There is also a small plantation containing a collection of the best varieties of Mulberry trees. Besides the magnanerie there is also a small filature of two basins used in testing the quality of cocoons.

The apparatus of the station consists of twenty microscopes, from several of the best makers, of plaster models, of maps, of incubators, etc., in a word, of all articles relating to silk culture.

Every month this station publishes a journal called "The Bulletin of Sericulture." (*Bulletino di Bachicoltura.*)

Every year there are two classes instructed; one of men, which lasts three months (April, May, and June), another of women (July and August). The station has done inestimable service for sericulture, it having granted diplomas to 250 pupils, who now occupy places in the sericultural observatories and spread their knowledge among silk-growers.

EXPERIMENTAL SILK FILATURE AT WASHINGTON.

The first reeling done in the experimental silk filature of the Department was during the week ending October 30, 1886. The consumption of the crop of the season of 1886 was terminated on August 13, 1887. During that period the work was not continuous, but was interrupted at various times and for various causes. In the nine and one-half months covered by the period mentioned, 1,057 pounds of

dry cocoons were consumed in the production of 263 pounds of reeled silk and 81¾ pounds of waste (*frisons*). Of these quantities, 556 pounds were cocoons of first quality and produced 143 pounds of reeled silk and 41 pounds of waste; and 501 pounds of second-grade cocoons produced 120 pounds of reeled silk and 40¾ pounds of waste.

We began the consumption of the crop of 1887 on the 15th of August, and have until the present time been principally occupied in the consumption of second-grade cocoons. It will be seen from the above figures that the rendition of the second-quality cocoons of 1886 averaged 4.271 pounds, or that 23.4 per cent. of the cocoons consumed were recovered in reeled silk and 8.1 per cent. in waste. It may be added that the limits of weekly rendition of these cocoons were 4.051 pounds, or 24.7 per cent., and 4.558 pounds, or 21.7 per cent. The second-grade cocoons of the crop of 1887 have given far better results than those of the previous crop, the average rendition having been 4.016 pounds of cocoons per pound of reeled silk, or 24.9 per cent., and the limits 3.895, or 25 per cent., and 4.152, or 24 per cent. The more uniform results obtained this year are due to the more thorough mixing of the cocoons of the various lots employed.

Very few first-grade cocoons of the crop of 1887 have been handled, but from those few we have been able to determine that the average results for the year will, with the first grade, as with the second, probably be better than were the best results for the previous crop. It will be possible to give figures substantiating this outlook only at the end of the year. It may, in general, be said that the cocoons received at the filature are better packed and show a greater degree of care on the part of the raisers than did those purchased a year ago.

PRODUCTION AND PURCHASE OF COCOONS.

The silk-growers of the United States are so few and are spread over so great an extent of country that it is impossible to collect any accurate statistics of the quantities of eggs which they incubate, or of the quantity of cocoons which they produce. The Department is therefore obliged to draw its conclusions as to the annual crop from the purchases made in the different filatures. The only purchasing stations of which the Department has any information are its own, at Washington; that of the Women's Silk Culture Association, at Philadelphia; that of the Kansas State Silk Station, at Peabody; and that of the State Board of Silk Culture, at San Francisco. The first two purchase from almost all the States east of the Rocky Mountains; the Kansas station from that State and the neighboring ones, and the California board from the Pacific slope. So far as they have been reported to us the purchases of dry cocoons have this year been as follows:

	Pounds.
Washington	2,213
Philadelphia	2,196
Peabody	1,765
Total purchases east of the Rocky Mountains	6,174

The purchases from the same area in 1886 were 5,115 pounds. The California board has not yet furnished us with statistics of its purchases.

As to the quality of the cocoons purchased this year we have already spoken. That they might have been better had they been stifled properly and in large quantities is also very apparent. The great importance of this systematic stifling has led us to give much thought to the matter and to try some experiments for the purpose of establishing the comparative value of our best American cocoons and of good cocoons of Italian production. For this purpose a quantity of Italian cocoons were imported this fall and the filature was occupied for a week in their consumption. The week before we had been employed in reeling a lot of first-grade American cocoons, well sorted, which had given us a weekly production of $13\frac{3}{4}$ pounds of silk, with a rendition of 3.557 pounds, or a recovery of 28.1 per cent. of silk. The Italian cocoons were, on the contrary, reeled just as they were received, without sorting, and while they gave a rendition of only 3.778 pounds, or 26.4 per cent., they gave a weekly production of $15\frac{1}{2}$ pounds of silk. The cause of the lower rendition was due to the lack of sorting, and of the improved production to the fact that the Italian cocoons were all stifled together, while the American lot was made up of a number of smaller ones, stifled by different persons, with the use of different methods, operated at different degrees of temperature. The importance of all cocoons in a lot being uniformly stifled appears in the cooking of the cocoons, for it is necessary to cook an overstifled cocoon longer in order to soften its gum than it is to cook one stifled at the proper temperature. The result then is, in a mixed lot, that in order to cook the overstifled cocoons we boil the others to pieces and they give off too great a proportion of waste.

It is hoped that special arrangements may be made to purchase fresh cocoons this year, thus enabling silk-growers to dispose of their crops and to receive their money therefor about three months earlier than usual, and at the same time avoid the possible destruction of their cocoons through improper stifling or care. The advantage to be derived by the Department through systematic and regular stifling will be such as to enable us to offer 40 cents a pound for the best fresh cocoons, which is equivalent to at least $1.20 for dry cocoons, instead of $1.15, the highest price yet paid.

One of the chief burdens hitherto imposed upon silk-growers has been the onerous transportation rates charged on their shipments, which in many cases have eaten up the profits, which at the best were small. In our earnest desire to establish this industry in the United States we shall do all in our power to lessen this burden the coming season. To what extent we can aid silk-growers in this matter will be stated more fully in a circular to be issued later in the year.

The importance both to the silk-growers and silk-reelers of the success of this plan to purchase fresh cocoons can not be overestimated, and this success will largely depend on the quantity of fresh cocoons which are purchased. And further, the ability of the silk-grower to send in his crop during the limited period when fresh cocoons are purchased must depend upon the promptness with which he puts his Silk-worm eggs to hatch upon the appearance of the first buds upon the food plants from which he intends to nourish his worms. While, however, early raising is strongly urged upon all silk-growers, it must not be forgotten that there is always danger from late frosts, which may kill the leaves and deprive the young worms of their food.

One of the best lots of cocoons that we have received at the filature this year was sent in by a lady living in Johnson County, Mo. She writes us in regard to the expense of raising these cocoons as follows: "Twenty dollars would cover the expenses (excluding labor) for both years that I have been engaged in the work, or $10 for each year. This year I incubated $3\frac{1}{2}$ ounces of eggs and raised $67\frac{3}{4}$ pounds of dry cocoons, for which the Department paid me $77.90. My mother and my four children assisted me in this work." It will be seen that the results obtained by this lady were but 58 pounds of fresh cocoons per ounce of eggs, whereas, as has already been stated, some of our correspondents have raised as much as 120 pounds, or more than .twice as many. These results were, however, obtained with quarter-ounce lots and would have been reduced with larger educations.

CO-OPERATING ORGANIZATIONS.

In addition to the work already described as done at this Department, the State of Kansas has been experimenting under authority of an act passed in 1887, having established a station at Peabody, in Marion County. They have been very active in their work, both in operating a non-automatic filature of eight basins and in disseminating information in regard to the industry throughout the State. The Women's Silk Culture Association at Philadelphia is continuing the experiments in reeling silk under a Congressional appropriation, and the Ladies' Silk Culture Society of California, under a like subsidy, is organizing for the coming season. The State of California has also continued to support its sericultural board, which claims to be doing excellent work.

Altogether the interest in the industry seems to be much more active throughout the country than it was a year ago, and we may safely say that a very material progress has been made during the past year toward the establishment of silk culture in the United States.

We urge the importance to this work of the formation of clubs for mutual benefit. Not of associations destined to help in spreading silk-growing, nor to distribute material, but of combinations of neighbors who may help each other by their experience and by an interchange of ideas. They may unite in the hibernation and incubation of their eggs, one hibernating box and one incubator intelligently managed being sufficient for all the silk-growers in a town. The season's work done, they may, if they can not sell their cocoons while fresh, again unite in the use of the same stifling apparatus and in the transportation of the cocoons to market. In all these operations such combinations will save much expense and, if the work be well directed, will realize material results in the increased size of the crop and the enhanced price received for the cocoons. Such clubs would form centers of information in each section and ultimately serve as nuclei for organization in making the strength of the silk industry felt in the national and State legislatures. Should this advice result in the formation of such bodies, the Department will assist them in every way in its power.

REPORTS OF AGENTS.

REPORT ON THE GAS TREATMENT FOR SCALE-INSECTS.

By D. W. COQUILLETT, *Special Agent.*

LOS ANGELES, CAL., *January* 20, 1888.

SIR: I have the honor to transmit herewith my report upon the gas treatment for scale-insects (*Coccidæ*).

Shortly after my re-appointment last July as an agent of your division the supervisors of this county withdrew their offered reward of $1,000 for a perfect exterminator of the Icerya, and their reason for so doing is thus given by the Los Angeles Herald:

"On Saturday last the board of supervisors decided to rescind the reward of $1,000 which they had offered for the discovery of a remedy which would exterminate the White Scale Bug and other pests injurious to fruit trees. They came to this decision for the reason that it is believed that Mr. Coquillett, the Government appointee, has by his gas system mastered the problem which has so long been a puzzle to all fruit-growers."

My experiments have been conducted in the orange groves of Mr. J. W. Wolfskill, of this city. Both Mr Wolfskill and his foreman, Mr. Alexander Craw, have aided me much in my work, as has also Mr. W. G. McMullen, one of the members of the Los Angeles County Horticultural Commission.

Your own advice and frequent expressions of confidence have done much toward giving to my work whatever of merit it may possess.

Very respectfully,

D. W. COQUILLETT,
Special Agent.

Prof. C. V. RILEY,
U. S. Entomologist.

THE GAS TREATMENT FOR SCALE-INSECTS.

The process of destroying insects on plants in hot-houses by fumigating with sulphur, tobacco, and various other noxious substances, has long been in vogue, but up to a recent date this mode of warfare against insect pests has not been extended to trees and plants growing in the open air. The earliest record I possess of any attempt of this kind is a copy of the specifications for a patent (No. 64667) granted to Mr. James Hatch, of Lynn, Mass., on the 14th of May, 1867. The following extracts from these specifications will sufficiently explain the method pursued by Mr. Hatch:

"The invention relates particularly to the manner of effecting the destruction of insects known as Canker-worms, after their lodgment in trees and while consuming the foliage thereof. * * * I cover the entire head of the tree with a thin cloth of close texture, drawing the edges around the trunk, so as to envelope the branches in a sort of sack. Near the tree I have a furnace, over which is placed a pan containing tobacco, pepper, or other substances, the smoke from which will stupefy or kill the worms; and from this pan I lead a pipe directly into the sack. Applying heat to the pan by a lamp or by fuel introduced into the furnace, the smoke generated from the tobacco or other substance in the pan is thrown into the sack and soon fills it, coming into contact with all the leaves, and either killing or instantly dislodging every worm and all other insects that may be in the tree."

This method of destroying insects on trees could not have been very widely adopted. Dr. A. S. Packard, who for several years held the office of entomologist to the Massachusetts State Board of Agriculture, writes me that he is not aware that this method has been practiced in any part of the Atlantic States. I can find no reference to it, nor to any similar method having been used in any of the States east of the Rocky Mountains from the date of the Hatch patent up to the present time.

For several years past many attempts at destroying scale-insects with gases and fumes have been made in southern California. For this purpose the infested tree was inclosed in an air-tight tent the lower part of which was either fastened around the trunk of the tree or allowed to fall upon the ground; in the latter case a small

quantity of earth was thrown upon the lower part of it, to prevent the escape of the gas or smoke. The tent was then filled with the smoke or gas experimented with.

Among the first to make experiments of this kind were Messrs. J. W. Wolfskill and Alexander Craw, of Los Angeles; Mr. John Wheeler, of San Francisco; Hon. J. DeBarth Shorb, Col. J. R. Dobbins, and Mr. B. M. Lelong, of San Gabriel. The substance most commonly experimented with was the liquid bisulphide of carbon (CS_2), but this did not prove entirely satisfactory, owing to the time required for it to evaporate and become diffused in the tent.

Probably no person has spent more time and money in trying to discover some effectual method for destroying the scale-insects with gas than has Mr. J. W. Wolfskill, of Los Angeles. In a paper read at a meeting of fruit-growers, held in this city on the 7th of October, 1887, Mr. Alexander Craw gave an account of the experiments made by Mr. Wolfskill and himself, from which we extract the following:

"Previous to the year 1884 we had only the Black Scale (*Lecanium oleæ*), to contend with in the Wolfskill orange groves, and these scales were easily kept in check by an application of whale-oil soap in the form of a spray; one application every two years was sufficient. In the fall of the year 1884 we found a few trees on the south side of the large grove infested with the Cottony Cushion-scale (*Icerya purchasi*); they became infested from an adjoining grove. We prepared for war, and soon had our spraying apparatus at work upon them. As we were in for extermination, we made a very strong solution of the whale-oil soap—so strong it almost defoliated the trees—and upon examination it looked as if we had gotten rid of the Icerya. A short time afterward, however, we found that the trees were again infested, and we sprayed again, using as much as 50 gallons of the solution to each tree; but even with all this care, some of the Icerya escaped and soon covered the trees again, spreading in a northeasterly direction through the grove. We then cut the trees back, letting the branches drop upon a large canvas and afterward burning them; we washed the stubs and trunks of the trees with the whale-oil soap solution, but even this severe treatment was not effective, so we concluded that spraying would not check this prolific creeping curse.

"Knowing the fatal effects of a high temperature upon the young of the Black Scale, Mr. Wolfskill suggested experimenting with heat; accordingly he had a tent constructed, and also a sheet-iron stove that would send the heat into the tent. We put the tent over an orange tree, and raised the temperature to 128° Fahrenheit for over an hour; this killed the Black Scales, but the Icerya seemed to enjoy the heat. The tree was injured, so we gave up dry heat. We next tried steam from a small steam-boiler; this cooked the top of the tree, but upon the lower half the Icerya were as lively as ever. Our next experiment was with tobacco smoke; this test lasted six hours, but had no effect upon the tree or scales. Sulphur fumes were also tried; this bleached the foliage, but did not harm the Icerya; a heavier charge killed both the tree and the scales. Among other experiments made under the tent were: Concussion from gunpowder; muriatic acid gas; carbonic acid gas; liquid chloroform, and also the gaseous chloroform manufactured under the tent from chloride of lime and methyl alcohol; arsenic, and other fumes and gases. We had very encouraging results from the liquid bisulphide of carbon; when confined for ten, twenty, or thirty minutes, or even for one hour, no satisfactory results were obtained, but when it was confined three hours it killed all of the scales, which soon assumed a pale buff color. The gas, being a very powerful solvent, also acted upon the eggs, and they were destroyed, while the trees were not injured; in fact, a few weeks afterward they started into a vigorous growth. Our efforts were then directed towards evaporating the bisulphide quickly; heat, steam-baths, agitation, circulating the air in the tent, exposing the bisulphide in shallow pans, and saturating sponges with it were tried, but without hurrying matters much.

"Prof. D. W. Coquillett was so well impressed with our method of treating trees that he decided to investigate the subject; accordingly, in the month of September, 1886, he began experimenting in the Wolfskill orange grove, and soon discovered that hydrocyanic acid gas would kill the scales and their eggs, but it also injured the foliage of the tree. We then united our efforts to remedy this evil, but it was something that required very close observation. We found that by withholding the water and allowing the sulphuric acid to come in contact with the dry cyanide of potassium in a fine stream we could treat trees without injuring even a blossom, while the gas proved fatal to the Black Scale (*Lecanium oleæ*), Red Scale (*Aspidiotus aurantii*), and the San José Scale (*Aspidiotus perniciosus*) confined in it ten minutes, but the Cottony Cushion-scale (*Icerya purchasi*) and eggs required a confinement of nearly thirty minutes.

"We then perfected an apparatus for putting the tent on tall trees quickly. This occupied a great deal of time, but we finally succeeded so well that we could change the tent from one tree to the other in less than two minutes. Mr. A. B. Chapman

and Mr. L. H. Titus, of San Gabriel, became impatient at the delay and requested Professor Hilgard, of the State University, to send them a chemist, and they would pay his expenses. In the month of April, 1887, Mr. F. W. Morse was delegated for this purpose, and he, too, finally discovered that hydrocyanic acid gas would kill the scales; but Professor Coquillett had made the same discovery over six months previously, so that the credit of this discovery belongs to this latter gentleman. Much credit is also due to Mr. J. W. Wolfskill for the great amount of time and money that he has devoted to this cause.

"ALEXANDER CRAW."

I am not aware that either of the other experimentors mentioned above have ever published the results of their experiments, nor have I been able to obtain any notes from them upon the subject.

Many years ago Dr. George Dimmock, one of the editors of Psyche, made a number of interesting experiments with pure gases on various insects, and his account of these experiments is given in the March-April number of that journal for 1877. The results obtained by him are briefly as follows:

"Carbonic acid gas (carbon dioxide) did not prove fatal to beetles confined in it for one or two moments, but several sow-bugs (*Oniscus*) confined in it from twenty to thirty minutes never recovered. Mixed with oxygen in the proportion of three parts of the former to one of the latter, it did not prove fatal to a beetle confined in it three minutes. When mixed in the proportion of sixty-six parts of the carbonic acid gas to thirty-four parts of oxygen, it did not prove fatal to a beetle confined in it five minutes, nor to a wire-worm (*Elateridæ*) confined in it thirty minutes, and of several sow-bugs (*Oniscus*) confined in it fifty minutes, to some it proved fatal while to others it did not.

"Carbonic oxide gas (carbon monoxide) did not prove fatal to beetles confined in it ten minutes, nor to butterflies confined in it thirty minutes.

"Hydrogen did not prove fatal to a beetle and butterfly confined in it five minutes.

"Oxygen did not prove fatal to a spider confined in it one hour, nor to a beetle confined in it for three days.

"Nitric oxide (NO) proved fatal to a beetle confined in it only fifteen seconds, while several sow-bugs (*Oniscus*) confined in it from forty to sixty seconds never recovered."

My own experiments with the nitric oxide mixed with air did not prove as successful as those made by Dr. Dimmock with the pure gas; in fact, the brown, fuming tetroxide proved more fatal to the Icerya than did the colorless oxids.

I first began experimenting with gases in the month of September, 1886, and have since continued it at intervals up to the present time; an account of these experiments will be found at the end of this report. Among the numerous gases tried none have given as good satisfaction as the hydrocyanic acid gas; an account of the discovery of the effects of this gas is given in the paper by Mr. Craw, reproduced above, and need not be repeated here. Several of the other gases experimented with by me have not as yet been given sufficient trial to justify me in reporting either for or against their use as insecticides.

In the month of April, 1887, several of the fruit-growers of San Gabriel, who had become acquainted with the results that Mr. Wolfskill, Mr. Craw, and myself had obtained with the hydrocyanic acid gas, applied to Prof. E. W. Hilgard, of the California State University, at Berkeley, for a chemist to assist them in experimenting with various gases, and he delegated Mr. F. W. Morse. Mr. Morse experimented with about half a dozen different kinds of gases, but found none so effectual as the hydrocyanic acid gas, which I had used over six months previously. His report will be found in Bulletin No. 15, Division of Entomology, of this Department. He was the first to use an apparatus for agitating the air in the tent, but this idea appears to have originated with Professor Hilgard, who writes me that he instructed Mr. Morse to always agitate the air in the tent after introducing the gas.

In the months of September and October, 1886, Mr. Albert Koebele, one of the entomological agents of this Department, made a few experiments with the liquid bisulphide of carbon, an account of which he gave in his report to Prof. C. V. Riley, published in the report of this Department for the year 1886, page 569. The results of these experiments, however, especially those made under a tent, are so discrepant as to leave one in doubt as to the value of the bisulphide as an insecticide.

During the past season I have made several experiments with the liquid bisulphide, the main object being to devise some method whereby it could be evaporated more quickly than by merely exposing it to the air, but the results of these experiments were not entirely satisfactory. I next manufactured the bisulphide by passing the vapors of sulphur over red-hot charcoal and conducting the gaseous bisulphide into the tent; but the numerous experiments I have made with the bisulphide

thus produced indicate that it can never be successfully used for the destruction of insects on trees.

THE TENT.

The tent used in inclosing the tree is of the usual circular form, with a conical or dome-shaped roof. It is usually made out of heavy bed-ticking, and is afterward thoroughly oiled with boiled linseed oil; care should be exercised not to leave the tent folded or rolled up while still damp with the oil. A tent belonging to Mr. J. W. Wolfskill, of this city, had been recently oiled, and when nearly dry was rolled up and thrown upon the ground where the sun shone upon it; this was in the forenoon, and when it was unrolled the next morning the greater part of it was found to be charred, as if by fire.

It would be desirable to use some kind of ready-prepared cloth for making the tent, but thus far no substitute for the oil-cloth has been found. I have received samples of water-proof cloth from the United States Water-proof Fiber Company, of New York, but even the heaviest grade, although evidently water-proof, is far from being air-tight. A sample of twilled sheeting, prepared especially for this purpose, is much closer in its texture than the above, but is not air-tight; they offer to furnish it at about 10 cents per yard, the heavy bed-ticking referred to above costing in Los Angeles about 19 cents per yard.

I have also received samples of rubber cloth manufactured by the Boston Rubber Company, of Boston, Mass. Their lightest and cheapest grade is a thin black cloth, which they offer to furnish and make into tents of any desired size, and with the seams closed up; the price would be about 23 cents per yard. This grade might answer for small tents—those not more than 5 or 6 feet high—but it is not strong enough for large-sized tents. At my request the company manufactured a tent about 12 feet high from this grade of cloth, but found that it was not strong enough for the use I intended to make of it.

They also sent three other grades of rubber cloth manufactured by them, and costing from 50 to 65 cents per yard made into tents; but it is doubtful that either of these grades would be strong enough for making large-sized tents.

I have also received samples of rubber cloth from the Goodyear Rubber Company, of San Francisco. Their light gossamer cloth is evidently not strong enough for making large-sized tents; its price is about 60 cents per yard. Their black rubber sheeting is the best that I have seen for this purpose, but the price, 54 cents per yard, would doubtless prevent its being used for this purpose.

APPARATUS FOR OPERATING THE TENT.

Where small trees are to be operated upon a sheet might be used for the purpose of confining the gas; or the sheet could first be sewed in the form of a sack, which could be easily slipped over a small tree from above, the operator standing on the ground, or upon a step-ladder. For operating on large trees, however, a device of some kind must be used for putting the tent on the tree, and also for removing it again.

The McMullen Tent.—This tent was originally devised by Mr. W. G. McMullen, of Los Angeles, and is designed for operating on trees not over 12 feet high. It consists of two upright wooden supports or legs, the upper ends of which are attached to the opposite sides of a circle made of round iron or steel rods; this circle is intended to pass around the inside of the tent at the junction of the roof and sides, and is supported by iron braces passing to the wooden supports or legs. The rafters or supports of the roof of the tent are three in number, and their upper ends fit into holes bored into a circular block of hard wood, which is retained in its place by the weight of the tent; the lower ends of two of these rafters are attached to the circle at the upper ends of the two braces on one side of the circle, while the lower end of the third rafter is attached to the circle at the upper end of the opposite wooden support, the three rafters thus forming a tripod. They should be perfectly straight instead of bowing outwardly.

The tent itself should be made several inches larger all around than the frame on which it is to be placed, to allow for shrinkage when oiled. For the purpose of holding the tent in its place on the frame, narrow strips of cloth may be sewed around the inside of the tent where the circle and rafters are to pass, the strips being wide enough to permit the circle and rafters to pass between them and the tent itself; or, what is still better, they may be sewed in the form of long tubes, through which the circle and rafters may afterward be passed.

On one side of the tent, midway between the two wooden supports, the tent itself is slit from the circle to the bottom of the tent, and a strip of cloth about 20 inches wide is sewed to the tent along either side of this opening, ex-

tending the entire length of the latter, the two strips to be sewed together at the top and for a distance of several inches down the side or front. Along the outer edge of each of these strips sew a wide seam, large enough to admit a piece of quarter-inch gas-pipe, which should be long enough to extend along the entire length of this opening in the tent. When these pieces of gas-pipe are in place, a strong piece of cord may be attached to each, near their lower ends, and passed through small pullies, fastened to the tent at the upper ends of the wooden supports or legs; by pulling down on these cords the door-way of the tent will be pulled wide open, so as to readily allow the tent to pass over the tree.

To accomplish this the two supports of the tent are lifted up by two persons and the tent is passed forward over the tree, after which the lower ends of the supports are allowed to sink into holes in the earth previously dug for this purpose, after which the holes should be filled up, the earth being packed quite firmly in them. The door-way of the tent is next closed by bringing its opposite sides together and wrapping the two pieces of gas-pipe, one around the other, fastening with strings sewed to the tent on either side of the door-way. The surplus cloth at the bottom of the tent is next spread out and earth thrown upon it to prevent the escape of the gas.

A tent of the above description has been used by myself and given very good satisfaction. I have recommended iron or steel rods for the frame of the tent, instead of gas-pipe, since the latter is very liable to break at the joints or couplings. There is yet need of a device of some kind by which the circle at the top of the tent could be made larger or smaller at the will of the operator, and also regulating the height of the wooden supports, so as to adapt the tent to the size of the different trees to be operated upon. The moving of the tent from tree to tree would be greatly facilitated if the wooden supports of the tent were attached to runners like those of a sled.

The Wolfskill Fumigator.—This apparatus was designed by Messrs. J. W. Wolfskill and Alexander Craw, of Los Angeles, and is the first that has been used with success upon the largest orange trees. A good idea of its appearance is given in Plate V.

This fumigator consists of a strong wooden frame mounted on a low wagon or truck; in the center is a tall mast, the bottom of which rests upon the wagon reach, which is strengthened by iron braces attached to the side pieces of the frame. The mast is placed between two pieces of pine timber and a stout iron pin passes through these pieces and through the mast. The bottom of the mast is kept in place by two blocks of hard wood bolted to the reach on either side of the mast; their inner ends are concave, so as nearly to encompass the lower end of the mast. For staying the mast four iron rods are attached at one end to the four corners of the frame on the wagon, while their upper ends are attached to an iron clamp which encircles the mast a little above the middle of the latter.

A short distance above this clamp is an arm or boom and its triangular brace, bolted together so as to encompass the mast; at either end of this arm is a frame carrying one main roller and two side rollers, the latter being placed at a distance of about 6 inches from either end of the main roller, and their office is to prevent the tent from passing off of the ends of the main roller while it is being drawn over the latter. For the support of these rollers and the triangular brace, iron rods are attached to the top of the mast and pass to either end of each of the roller frames, and also to each outer corner of the triangular brace, while two other iron rods are fastened at one end to each outer corner of this brace, their other ends being fastened to one of the wooden side pieces of the frame on the wagon. An iron rod also passes from each outer corner of the triangular brace to either end of the roller frame at the outer end of the arm to prevent side motion.

The tent is drawn off of the tree by means of a rope that passes through the two main rollers and down the mast to a windlass attached to the frame of the wagon, extending from one side piece to the other, and passing just behind the mast; by turning this windlass the tent is drawn off of the tree, passing over the main roller at the outer end of the arm, then over the one at the opposite end, and down the mast till the bottom of the tent has been elevated above the tops of the highest branches of the tree. At the bottom of the tent is fastened a circle of gas-pipe, for the purpose of keeping the bottom of the tent spread out while it is passing down over the tree; iron or steel rods made into a circle would be preferable to the gas-pipe, which is liable to break at the joints or couplings. To this circle are attached two or three ropes, to be used in pulling the tent down over the tree. The main rollers at either end of the arm are provided with a deeply-grooved pully in the center of each, over which the rope passes in drawing the tent off of the tree, or allowing it to pass down over one.

When it is desired to transport this fumigator to a considerable distance the mast is lowered by means of a derrick composed of four pieces of pine timber; the lower

ends of the foremost pieces are attached to the front corners of the frame on the wagon, while the ends of the other two pieces simply rest upon that frame on either side of the mast. The upper ends of these pieces are fastened together by a strong iron bolt, to which a large pulley is attached. In lowering the mast a large rope is attached to it just above the point where the iron clamp encircles it; the other end of the rope is then passed through the pulley at the upper end of the derrick, and from this point it passes to the windlass, upon which the rope is then wound. The block of wood bolted to the wagon reach in front of the mast is then removed, and the stay-rods fastened to the frame on the wagon are disconnected; then, by unwinding the windlass, the mast is lowered until it rests horizontally upon the wagon, turning upon the iron pin that passes through the mast near its base.

I have used this fumigator repeatedly, and it has given good satisfaction when used on level ground and at a time when the wind was not blowing very hard. Two men can operate it with ease. For transporting from place to place it is the best apparatus that has yet been produced. It is desired to have the stay-rods and windlass attached to a turn-table, so that the tent could be taken off of one tree and put upon another without moving the wagon; by this arrangement three tents could be operated by the one apparatus without any loss of time. It might also be desirable to mount this apparatus upon runners, like those of a sled, but placed as wide apart as the trees would admit.

This fumigator has not been patented up to date.

The Titus Fumigator.—This apparatus was devised by Mr. L. H. Titus, of San Gabriel, and is especially designed for operating on tall trees. It is shown in Plate IV, and consists of four corner posts made by bolting together two boards in such a manner that they form a right angle with each other; at the upper ends these posts are connected by cross-pieces formed of boards bolted together like those forming the corner posts. Two of these cross-pieces are longer than the other two, and are placed on opposite sides of the frame; they are connected near the middle by two cross-pieces, between which is placed the roller upon which the tent is to be wound when being drawn off the tree. These various cross-pieces are braced, as shown in Plate .

The lower end of each of the rear corner posts is rigidly attached to an axle, on the outer end of which a light wheel is placed, while the inner end is connected with the corner post by an oblique brace. The lower end of each of the front corner posts is attached to the middle of an axle having a light wheel at each end; the post is attached to the axle by an iron bolt, which permits the wheels to be at the same moment turned, the one forward and the other backward, like the forward wheels of a wagon or buggy. By means of this arrangement the fumigator can be turned about in a circle. The front and rear corner posts on each side of the fumigator are connected with each other by a cross-piece extending from one to the other, and strengthened by braces which extend obliquely from the cross-piece to the posts. When this fumigator is in use the front and rear cross-pieces shown in Plate IV as extending from the posts on the one side to those on the other are removed, so as to permit the frame to pass either forward or backward over the trees.

The top of the tent is attached by three ropes to the roller, while to the lower edge of the tent are attached four ropes, placed at equal distances from each other; each of these ropes passes through a pulley attached to a frame near each upper corner, and the end of the rope is attached to the lower edge of the tent at the place where the opposite end of the same rope is attached. For winding the tent upon the roller an endless rope is used; this passes around a grooved wheel at one end of the roller and is carried through a pulley near the upper end of one of the rear corner posts; from this point it passes to and around a grooved wheel fastened to the cross-piece near the lower end of this post, and this grooved wheel is operated by a crank.

In taking a tent off of a tree each of the corner ropes is pulled through its pulley, drawing the bottom of the tent upward, thus turning the tent inside out; after the tent has been drawn up as far as possible, the crank operating the grooved wheel that works the endless rope is turned, winding the tent upon the roller until it has been entirely removed from the tree. The fumigator is thus drawn forward until the tent is brought directly over the second tree, when the ropes attached to the lower edge of the tent are loosened, permitting the tent to drop down over the tree, at the same time unwinding the tent from the roller, and continuing this until the tent rests upon the tree.

I have helped to operate a fumigator of this kind several times, and it gave very good satisfaction, especially the manner in which the tent was let down over the tree and taken off again. The frame of the fumigator should be so constructed as to admit of its being lowered when not in use, to prevent its being injured by high winds; three of these fumigators have, to my knowledge, been totally wrecked by high winds within the last three months. There is also need of some device by which one of these apparatuses could operate two or three tents.

I am not aware that this fumigator has as yet been patented, although I am of the opinion that the inventor has applied for letters patent.

The Culver Fumigator.—This fumigator was devised by Mr. John P. Culver, of Los Angeles, who, on the 26th of July, 1887, obtained a patent on the same (No. 367134). While both the Wolfskill and the Titus fumigators allow the tent to pass down over the tree from *above*, the present one incloses the tree from one side, being made in the form of two half-tents, which encompass the tree and meet upon the opposite side. A very good idea of this fumigator can be gleaned from Plate VI.

The frame-work of the tent may be constructed either of wood or of band iron, and the covering may be a light grade of tin or a heavy grade of canvas or of bed-ticking well oiled with boiled linseed oil. The edges, which are to meet when the tent is closed, should be covered with a thick layer of felt.

The tent is transported from tree to tree upon a pair of runners, like those of a sled, fastened together by several cross-pieces, one of which is exactly in the middle, and near one end of this cross-piece is firmly attached an upright post, tall enough to reach a little above the lower edge of the roof of the tent; this post is further strengthened by two wooden braces attached to it near its upper end, their lower ends being attached to the runner on the opposite side of the sled. The two halves of the tent are attached to the post by means of four hinges, two of which are attached to the frame of the tent near its lower edge and not far from the juncture of the two halves, while the other two are attached to the frame near the lower edge of the roof. The opposite ends of these hinges are attached to upright rods fastened to the post near its upper and its lower ends, and are so arranged as to allow the tent to be raised or lowered, independent of the post; they are so constructed that when the tent is being closed it is pushed forward until it is entirely clear of the sled, so that when the tent is closed it can be dropped upon the ground. The raising and lowering of the tent is accomplished by means of a lever applied to the frame of the tent near the point where one of the lower hinges is attached.

In taking the tent off of the tree the tent is first raised up with the lever until its lower edge is above the upper side of the sled, after which the tent is opened and the two halves are swung around and allowed to rest upon the sled, as shown in Plate VI. The sled is then drawn forward until the junction of the two halves of the tent is brought opposite to the middle of the second tree, when the tent is slightly raised by the lever and the two halves swung around until they inclose the tree, after which they are fastened together and dropped upon the ground. The hinges at the upper end of the upright post on the sled are so constructed as to allow the tent to lean either backward or forward, so that its lower edge may conform to the surface of the ground.

I have been able to make only a single test with a fumigator of this kind, and it gave very good satisfaction. I am of the opinion that this fumigator will prove to be both cheaper and easier to operate than either of those described above. There is still need of some device by which the same tent could be made smaller or larger at the will of the operator, so that it may be made to conform to the size of the different trees. Mr. Culver, the inventor, informs me that he intends to use two of these fumigators, transmitting the gas from one tent to the other, but it is impossible at the present writing to say whether or not he will meet with success, as no tests of this kind have as yet been made. If successful, this method would reduce the cost of treating a tree at least one-half.*

THE GAS.

Among the numerous gases which I have tried none have given such good results as the hydrocyanic acid gas; even arseniureted hydrogen and sulphureted hydrogen, which are so fatal to the higher animals when respired, fail to produce the same deadly effects upon the scale-insects that is produced by the hydrocyanic acid gas.

The latter, when generated in the usual manner, by acting with sulphuric acid upon potassium cyanide dissolved in water, is very destructive to the foliage of the trees confined in it. To remedy this three methods are at present known, viz: The *dry cyanide* process, which consists of acting upon the dry potassium cyanide with sulphuric acid; the *dry gas* process, consisting of acting with sulphuric acid upon potassium cyanide dissolved in water and passing the gas through sulphuric acid; and the *cyanide and soda* process, which consists of mixing bicarbonate of soda with potassium cyanide dissolved in water and adding the mixture to sulphuric acid.

The dry Cyanide Process.—In my early experiments with this gas it was plainly

*Mr. Coquillett writes later: "The tent of the Culver fumigator is now made without a frame-work, except the two arches; this makes it both cheaper and lighter than before, permitting the tent to more nearly conform to the shape of the different trees confined in it."—C. V. R.

to be seen that the less water the cyanide has been dissolved in the less injurious was the effect of the gas upon the tree confined in it. The heat generated in the production of the gas is sufficient to vaporize a considerable quantity of the water in which the cyanide has been dissolved, and this aqueous vapor collecting upon the leaves would condense the gas, which is very soluble in water, forming hydrocyanic acid, which is very destructive to plant life. It is also probable that the ascending vapor carried with it some of the unchanged cyanide solution, since it was clearly apparent that the gas was more injurious to the foliage when generated rapidly than when it was produced more slowly. Profiting by this discovery I next tried acting with the acid upon the dry, finely pulverized cyanide, and the result proved that the gas thus produced was less injurious to the foliage than when generated in the usual way. It still injured the leaves to a certain extent, due, as it appears, to the fact that the ascending gas carried with it some of the fine particles of the cyanide and lodged them upon the leaves. My next step was to use the cyanide in large pieces instead of pulverizing it, and the gas thus produced did not injure the tenderest leaves of orange trees, even when confined in it for an hour. The proportion of ingredients used was about two fluid ounces of sulphuric acid to each ounce of the potassium cyanide.

Muriatic acid may be used instead of the sulphuric, but it is not as strong, besides costing more. Only the best grade of the cyanide, such as that commonly used by photographers, can be used for this purpose, since the cold acid will not act upon the poorest grade, which is commonly used for mining purposes; and this remark is equally true in regard to both of the processes described below.

The dry Gas Process.—I have already alluded above to the fact that the drier the gas the less injurious was the effect upon the tree confined in it; and it occurred to me that the gas might be generated in the usual way, by acting with sulphuric acid upon potassium cyanide dissolved in water, and afterward be dried by passing it through some medium that would deprive it of its moisture. Knowing the great avidity of sulphuric acid for moisture, I determined to use it as a drier for the gas, and several tests which I have made with this gas dried in this way prove that it does not injure the foliage of orange trees confined in it, while it is just as fatal to the scale-insects as is the moist gas. The density of the acid through which the gas had passed was lowered about one degree, as indicated by the hydrometer; but this would not prevent its use for generating the gas.

The cyanide is dissolved by boiling in water for a few minutes, using 1 gallon of water for each 5 pounds of cyanide. It is desirable to use as little water as possible for this purpose, but the quantity could not be very much reduced from that given above; I have tried to dissolve 5 pounds of the cyanide in half a gallon of water, but all of the cyanide had not dissolved after half an hour's boiling. For every ounce of the cyanide solution use half an ounce of sulphuric acid, but it is always desirable to add some of the acid to the prescribed dose, in order that there may be an excess of the acid. No evil results will follow if double the proper quantity of the acid were to be used, whereas if less than the proper quantity were used the whole of the gas would not be evolved from the cyanide solution; hence the advisability of always using an excess of the acid.

In generating the gas the acid should flow upon the cyanide solution in a very fine stream. When they come in contact violent action at once takes place, and the gas is rapidly given off in the form of a dense whitish fog, resembling smoke and possessing a peculiar odor. When this gas, diluted with air, is inhaled, it produces a dryness in the mouth and throat.

It is impossible to give any definite rule for using the different ingredients that will apply to the differently sized trees, owing to the fact that trees of the same height may have a varying diameter of top; thus orange trees 12 feet tall may have a diameter of top ranging all the way from 6 to 10 feet. The manner in which the tree is pruned will also make a difference in the quantity of the ingredients to be used, some trees being allowed to branch almost from the ground, while others are trimmed up from 3 to 5 feet from the ground.

The following table, based upon numerous experiments which I have made on orange trees under a tent 10 feet tall and having a transverse diameter of 10 feet, will give a good idea of the proper quantities of each ingredient to be used in treating citrus trees:

Height (in feet).	Diameter (in feet).	Cyanide solution (fluid ounces).	Sulphuric acid (fluid ounces).
6	5	2	1¼
10	10	12	7
12	8	9	5
16	12	28	16
20	14	47	26

This table is based upon the cubical contents of the space inclosed by the tent, supposing that the lower part of the tent rests upon the ground. No harm will result to the tree if twice the quantity that I have recommended be used, but of course, for the sake of economy, it will be desirable to use only such quantity of each ingredient as will be necessary for destroying the scale-insects infesting the tree to be treated with this gas. The sulphuric acid should have a density of 65° when tested with an acid hydrometer; should its density be lower than this, use an extra ounce of the acid for every five degrees of density below 65°.

The Cyanide and Soda Process.—The third method of rendering the hydrocyanic acid gas harmless to the foliage of the trees confined in it consists o mixing this gas with carbonic acid gas, the latter having the property of extracting the moisture from the former, forming gaseous carbonic acid. This appears to occur only under a certain degree of pressure; thus, if the two gases are generated in the same open generator within the tent and allowed to rise and fill the tent, the hydrocyanic acid gas will prove nearly as injurious to the foliage of the tree confined in it as it would if no carbonic acid gas had been present.

The carbonic acid gas is produced by acting with sulphuric acid upon bicarbonate of soda or saleratus. The latter is first made into a thin paste with water, using about 1 fluid ounce of water to each 2 ounces by weight of the bicarbonate. Several seconds elapse after the sulphuric acid comes in contact with the soda paste before the evolution of the gas begins; a foamy mass soon appears, consisting of variously sized bubbles which rise up in the generator and finally burst, giving forth the colorless and odorless gas. A fluid ounce of the acid will evolve all of the gas from about 3 ounces of the bicarbonate, weighed before it is mixed with the water.

The bicarbonate has a tendency to settle to the bottom of the solution, forming a compact mass upon which the acid acts very slowly. On this account it is desirable to add the soda paste to the acid instead of following the usual method of adding the acid to the soda. I have used marble dust in place of the bicarbonate of soda, and the result obtained by its use was as satisfactory as when the bicarbonate had been used; it possesses none of the adhesiveness of the bicarbonate and consequently does not form a compact mass in the bottom of the solution.

The best results have been obtained when both the hydrocyanic acid gas and the carbonic acid gas were produced in the same apartment of the generator.

The cyanide is first dissolved in water, as described above, using 5 pounds of the cyaniole to each gallon of water, and for every 10 fluid ounces of this solution use 9 ounces, by weight, of the bicarbonate. The bicarbonate is first made into a thin paste with water, as above described, after which it is added to the proper quantity of the cyanide solution and thoroughly stirred; the whole is then added very slowly to the proper quantity of sulphuric acid, previously poured into the lower apartments of the generator.

The following table will give a good idea of the proper quantity of each ingredient to be used for the differently sized trees:

Height (in feet).	Diameter (in feet).	Cyanide solution (fluid ounces).	Bicarbonate of soda (ounces by weight).	Sulphuric acid (fluid ounces).
6	5	2	$1\frac{4}{5}$	$1\frac{1}{4}$
10	10	12	11	11
12	8	9	8	8
16	12	28	27	25
20	14	47	43	40

The hydrocyanic acid gas will be just as effective if twice the amount of the bicarbonate of soda that I have recommended be used, together with a sufficient quantity of sulphuric acid to evolve all of the carbonic acid gas from it. This latter gas does not act as a diluent, as some persons have supposed, but simply as a drier, its sole office being to extract the moisture from the hydrocyanic acid gas, thus rendering the latter gas harmless to the foliage of the trees confined in it.

The carbonic acid gas does not injure the foliage of orange trees confined in it; when sufficiently pure, it stupefies the scale-insects confined in it for half an hour, but they wholly recover from the effects of the gas after the lapse of a few hours.

I noticed that when the trees were treated with the cyanide and soda process in the hottest part of a very hot day the foliage was almost as severely injured as when the hydrocyanic acid gas had been used alone. We may conjecture that this results from the fact that at a high temperature the carbonic acid gas is freed from the aqueous vapor, leaving the latter in a proper condition for again uniting with

the hydrocyanic acid gas. When these two gases are reduced to the liquid state by pressure or by great cold, it is found that the liquid carbonic acid boils at a much lower temperature than the liquid hydrocyanic acid does. A given quantity of water will dissolve about its own volume of carbonic acid gas, but all of this gas thus may afterward be expelled by boiling.

Remarks.—Of the three processes described above, it is evident that the dry gas process is preferable to either of the others. Not only is there less labor in its manipulation, but it is also much cheaper than either of the other processes; this will readily appear from the following estimates of the cost of the material necessary for treating an orange tree 20 feet tall and having a diameter of top of 14 feet:

Dry cyanide process.

24 ounces potassium cyanide, at 5 cents per ounce	$1.20
52 fluid ounces sulphuric acid, at $1\frac{3}{13}$ cents per ounce	.64
Total	1.84

Dry gas process.

47 fluid ounces cyanide solution, at $2\frac{1}{2}$ cents per ounce	$1.20
26 fluid ounces sulphuric acid, at $1\frac{3}{13}$ cents per ounce	.32
Total	1.52

Cyanide and soda process.

47 fluid ounces cyanide solution, at $2\frac{1}{2}$ cents per ounce	$1.20
43 ounces bicarbonate of soda, at $\frac{1}{2}$ cent per ounce	.21
40 fluid ounces sulphuric acid, at $1\frac{3}{13}$ cents per ounce	.49
Total	1.90

These prices are those current in Los Angeles when the various ingredients are purchased in small quantities at retail; when purchased in large quantities they could be obtained at a much lower rate. Mr. A. Scott Chapman, of San Gabriel, a member of the California State Board of Horticulture, informs me that he purchases the best grade of potassium cyanide in large quantities at the rate of 50 cents per pound, and I have been shown a letter, addressed to Mr. J. W. Wolfskill, of this city, wherein a firm in Saint Louis, Mo., offered to furnish commercial sulphuric acid of the best grade at the rate of 2 cents per pound, net; the freightage on this acid from Saint Louis to Los Angeles would amount to about 5 cents per pound, making a total cost of 7 cents per pound for the acid delivered at Los Angeles. At these prices the cost of treating an orange tree 20 feet tall and 14 feet in diameter, by the dry gas process, would amount to about $1, not reckoning in the labor and interest on money expended for the apparatus.

After the tree has been confined in the gas the proper length of time the tent should be entirely removed from it. On two different occasions I simply opened the tent to allow the gas to escape, after which the tent was again placed on the tree and the doorway of the tent left partially open; it remained on one of the trees for seven consecutive days, while on the other tree it was allowed to remain only for a day and night, but in both instances the trees were nearly killed.

The generator used in the production of the hydrocyanic gas is as shown in the foreground in Plate V; it was originally devised by Mr. Alexander Craw and myself, and has given perfect satisfaction.

This generator consists of two leaden vessels placed one above the other and connected by a brass stop-cock; to the end of the valve of this stop-cock is firmly soldered an L-shaped piece of an iron rod, to be used in opening and closing the stop-cock. The lower vessel is entirely closed above; near one side of the top is a screw-cap, covering the opening through which the proper chemicals are to be introduced into the vessel, while on the opposite side is an opening over which is firmly soldered the end of a leaden pipe, through which the gas passes on its way from the generator to the tent. When it is intended to pass the gas through sulphuric acid this leaden pipe is made to enter one side of an upright leaden vessel, and as near the bottom of the vessel as possible; to the top of the leaden vessel is attached a tin or leaden pipe which conducts the dried gas into the tent. Of course, if it is not desired to pass

the gas through sulphuric acid the leaden acid-vessel can be dispensed with, the leaden pipe from the generator passing directly into the tent.*

In charging the generator for the dry gas process, the proper quantity of the potassium-cyanide solution is poured into the lower vessel through the opening closed by the screw-cap, this cap having first been removed, to be again replaced after the solution has been poured in. The stop-cock connecting the two vessels of the generator is next closed by turning the handle attached to the valve, after which the proper quantity of sulphuric acid is poured into the upper vessel. The tin pipe attached to the upper end of the leaden acid-vessel is then removed, and a slightly larger quantity of sulphuric acid is poured into this vessel than was poured into the upper vessel of the generator; there should be a sufficient quantity of the acid in this leaden vessel to slightly more than cover the end of the leaden pipe leading from the generator. The tin pipe is next attached to the upper end of the acid-vessel, as shown in Plate V, while the other end of this pipe passes into the tent previously placed over a tree and made ready for the reception of the gas.

When everything is ready the handle of the stop-cock of the generator is turned until the acid in the upper vessel commences to flow into the lower one, where it comes in contact with the cyanide solution, and the production of the gas begins. The acid should be allowed to flow very slowly upon the cyanide solution; if the gas is produced too rapidly the acid will be thrown out of the acid-vessel; the latter should be taller than indicated in Plate V, and it would doubtless be an advantage to have it wider at the top than at the bottom.

After all of the gas has passed into the tent, the acid in the acid-vessel should be emptied into a glass or leaden vessel to be used the next time for generating the gas; for this purpose it would be well to insert a brass stop-cock in the lower part of the acid-vessel. There should also be quite a large stop-cock in the lower part of the lower vessel of the generator, for drawing off the residue before again charging the generator with fresh materials. When not in use the two vessels of the generator, and also the acid-vessel, should contain a small quantity of water, which will prevent the valves of the stop-cocks from becoming so corroded that they can not be operated without first being taken apart and cleaned.

AGITATING THE AIR IN THE TENT.

After the gas has passed into the tent, and also while it is passing in, the air in the tent should be thoroughly agitated. The most effectual method of accomplishing this is by the use of some device whereby the air may be drawn out of the top of the tent and forced in at the bottom. When the McMullen or the Culver tent is used, the pipe taking the air out of the upper part of it can enter the top of the tent, but in the Wolfskill and the Titus tents both pipes must enter the tent at the bottom, the one intended for drawing the air out of the upper part of the tent passing some distance up the trunk of the tree, while the other pipe merely passes a short distance into the tent.

For circulating the air in the tent various devices have been used, but the one that has given the best satisfaction is known as the Cummin's blower, which was originally intended for forcing air into mines. It consists of an iron fan-wheel, driven with great velocity by means of a series of cog-wheels and pinions, the whole encased in an air-tight iron covering, having an opening on one side of the fan-wheel, through which the air is drawn out of the tent by means of a tin pipe, the base of which covers this opening. In the lower part of the fan-wheel chamber is a large opening, placed opposite to a similar opening in one side of an iron pipe closed at one end while to the other end is attached the tin pipe through which the air is to be forced into the tent. When the crank operating the fan-wheel is turned the air is drawn out of the tent through the tin pipe, and passes into the fan-wheel chamber through the hole in the side of the latter, and by the rapidly revolving fan-wheel is thrown by centrifugal force into the tent.

I had a blower constructed upon nearly the same principle as the above, except that the fans were made of tin, as was also the covering of the fan-wheel chamber, but it did not give very good satisfaction.

There is a machine manufactured at San José, Cal., and known as the Acme fumigator, which is provided with an iron fan-wheel driven by a belt. The blower

*Mr. Coquillett writes later as follows: "In speaking of the gas generator I recommend passing the gas *through* sulphuric acid; a better way is to pass it *into* the acid, the leaden pipe which conducts the gas from the generator entering the upright leaden vessel above its middle, and curving downward in the vessel until the mouth of the pipe nearly reaches the bottom of the vessel and is covered by the acid."—C. V. R.

of this fumigator is much too small to be used for agitating the air in the tent, but the manufacturer, Mr. A. R. Tomkin, informs me that they could be made of almost any size, and that the price would be less than a third of that of the Cummin's blower. This is a very simple arrangement, and if made large enough would doubtless answer the purpose quite as well as the Cummin's blower, and at a much lower price.

It has also been suggested to use a common blacksmiths' bellows for the purpose of stirring the air in the tent, but it would appear to be a difficult task to manipulate it in such a way that the air would be drawn out of the tent as well as forced into it.

In the Culver tent a wooden fan is at present used, being placed inside of the tent as shown in Plate ; a fan of this kind, however, will always cause more or less trouble on account of its striking the branches of the tree inclosed by the tent. On this account it is advisable to always have the apparatus for agitating the air in the tent placed on the outside of the latter.

Whatever form of apparatus is used, it should be placed as near as possible to the point where the gas is to enter the tent; and if it can be so arranged that the gas can pass into the tent by the same pipe through which the air is forced into the tent, this will be a great advantage, since the gas will then become more thoroughly mixed with the air in the tent before reaching the foliage.

EXPERIMENTS.

Of the following experiments, those from 1 to 91, inclusive, were made upon small orange trees by covering them with a common five-gallon tin kerosene can, the upper end of which had been cut out, the gas being generated under the can after the latter had been placed over the trees. Experiments from 92 to 130, inclusive, were made by the use of a tent having a diameter of 10 feet; the height of the trees is given in the different experiments; the trees experimented upon were orange, except where otherwise stated. Measurements of liquid are given in fluid ounces and fractions of solids by avoirdupois weight.

(1) Diluted one part of commercial nitric acid with two parts of water. Took five-eighths of an ounce by weight of brass filings and one-half fluid ounce of the diluted acid. Confined it ten minutes. Thirty minutes later some of the Iceryæ were crawling about; three days later all of the leaves were dead, while nearly all of the Iceryæ were alive.

In this, and also in experiments from 2 to 5, inclusive, no red fumes were given off when the acid came in contact with the brass filings; in each the residue was of a bluish color.

(2) Took five-eighths of an ounce of brass filings and 1¼ fluid ounces of the diluted nitric acid. Confined it twenty minutes. All of the leaves but only a few of the Iceryæ were killed.

(3) Took one-third ounce brass filings and 1¼ ounces of the diluted nitric acid. Confined it fifteen minutes. Result same as in the preceding experiment.

(4) Took one-sixth ounce brass filings and 1¼ ounces of the diluted nitric acid. Confined it fifteen minutes. About eleven-twelfths of the leaves were killed; Iceryæ scarcely affected.

(5) Took one-thirteenth ounce brass filings and 1 ounce of the diluted nitric acid. Confined it fifteen minutes. About three-fourths of the leaves but only a few of the Iceryæ were killed.

(6) Took one-fifth ounce brass filings and one-fourth fluid ounce of pure nitric acid. Confined it ten minutes. About three-fourths of the leaves were killed; Iceryæ scarcely affected.

In this and the three following experiments dense brownish fumes were given off the moment the acid came in contact with the brass filings, and the residue was of a bluish-green color.

(7) Took one-fifth ounce brass filings and one-third ounce pure nitric acid. Confined it fifteen minutes. All of the leaves and about one-half of the Iceryæ were killed.

(8) Same as 7. Result the same; the dead Iceryæ were mostly situated on the upper part of the tree.

(9) Took one-eighth ounce brass filings and one-third ounce pure nitric acid. Confined it twenty minutes. All of the leaves and about one-half of the Iceryæ were killed.

(10) Took one-fourth ounce Paris green and one-half ounce pure nitric acid. Confined it fifteen minutes. Neither the leaves nor the Iceryæ were affected; the latter were as lively as ever a few minutes after removing the tin can.

(11) Took one-sixth ounce brass turnings and two-thirds ounce pure nitric acid.

Confined it fifteen minutes. All of the leaves and about nine-tenths of the Iceryæ were killed.

(12) Took one-twelfth ounce brass turnings and one-third ounce pure nitric acid. Confined twenty-five minutes. All the leaves and four-fifths of the Iceryæ were killed.

The skins of the dead Iceryæ in this and the preceding experiments soon became very dark colored and soft, readily breaking.

(13) Took one-fifth ounce brass filings and one-half ounce pure nitric acid. Confined it twenty-five minutes. All the leaves were killed and all the Iceryæ on the upper part of the tree, but scarcely one-half of those on the lower part were killed.

Whenever the brass filings were used, the leaves showed the destructive effects of the gas much sooner than when the turnings were used.

(14) Took one-sixth ounce pure zinc and five-sixth ounce pure nitric acid. Confined it twenty-nine minutes. Residue colorless. All of the leaves were killed and about one-half of the Iceryæ on upper part of tree, but only one-fourth of those on the lower part were killed.

(15) Dissolved one-half ounce of arsenic in 2 ounces of water in which one-half an ounce of caustic soda had been dissolved. Took 2½ ounces of water and two-fifths of an ounce of the arsenic-soda solution. Confined it twenty minutes. Leaves uninjured; about one-third of the Iceryæ were killed.

(16) Took 2½ ounces of water and 1 ounce of the arsenic-soda solution. Confined it twenty minutes. Leaves uninjured; very few of the Iceryæ were killed.

(17) Took 1 ounce of mercury and 1 ounce pure nitric acid. Confined it twenty minutes. One-tenth of the leaves and nearly all of the Iceryæ were killed. Residue colorless, but becoming bluish upon adding water to it.

I can not account for the good results obtained in this experiment. I have frequently tried to repeat it, but always without success.

(18) Took one-half an ounce of mercury and 1½ ounces pure nitric acid. Confined it twenty minutes. Leaves scarcely affected; about one-fourth of the Iceryæ were killed.

(19) Took one-eighth ounce pure tin in small pieces and 1 ounce pure nitric acid. Confined it twenty minutes. Residue nearly milk-white. Leaves uninjured; about one-fifth of the Iceryæ were killed.

(20) Took one-eighth ounce tin and 2 ounces nitric acid. Leaves uninjured; no Iceryæ killed.

(21) Took one-half ounce of mercury and 1½ ounces nitric acid. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(22) Took three-fourths ounce mercury and two-thirds ounce nitric acid. Confined it twenty minutes. Nearly all the leaves but none of the Iceryæ were killed.

(23) Took one-twelfth ounce pure copper in small pieces and 1½ ounces nitric acid. Confined it twenty minutes. Residue deep blue. All of the leaves and about one-sixth of the Iceryæ were killed.

(24) Took 3½ ounces of water and 1½ ounces of the arsenic-soda solution of experiment 15. Confined it twenty minutes. Leaves scarcely injured; only a few of the Iceryæ were killed.

(25) Put 1 ounce of sal ammoniac in 3 ounces of water; all of the sal ammoniac had not dissolved after the lapse of several hours. Took 2 ounces of this solution and added it to three-fourths of an ounce of quicklime. Confined it twenty minutes. All of the leaves but none of the Iceryæ were killed.

(26) Took an ounce of the sal ammoniac solution and added it to one-half an ounce of quicklime. Confined it twenty minutes. All of the leaves but none of the Iceryæ were killed.

(27) Took one-sixth of an ounce of naphthaline and 1½ ounces nitric acid. Confined it twenty minutes. One-third of the leaves but none of the Iceryæ were killed.

(28) To residue of above was added half an ounce of quicklime. Confined it twenty minutes. One-tenth of the leaves and one-half of the Iceryæ were killed.

(29) Took half an ounce of mercuric chloride and 1½ ounces nitric acid. Confined it twenty minutes. Leaves uninjured; about one-fourth of the Iceryæ were killed.

(30) To residue of above was added one-half an ounce of quicklime. Confined it twenty minutes. One-third of the leaves and one-fourth of the Iceryæ were killed.

(31) Took one-sixth ounce mercuric chloride and 1 ounce of nitric acid; added one-half an ounce of quicklime. Confined it twenty minutes. One-fourth of the leaves were killed; Iceryæ uninjured.

(32) Took one-fourth ounce of mercurious ointment, composed of lard and mercury, and three-fourths ounce of nitric acid. Confined it twenty minutes. Leaves uninjured; only a few Iceryæ were killed.

(33) To above residue was added three-fourths of an ounce of quicklime. Confined it twenty minutes. No leaves and but few Iceryæ were killed.

(34) Took one-third ounce of arsenic and 1½ ounces of nitric acid. Confined it twenty minutes. Residue greenish. A few leaves at the top of the tree and a few of the Iceryæ were killed.

(35) To residue of above was added three-fourths of an ounce of quicklime. Confined it twenty minutes. All of the leaves and about one-sixth of the Iceryæ were killed.

(36) Put half an ounce of arsenic in 2 ounces of water, and allowed it to stand for several hours. Added three-fourths of an ounce of quicklime to 1½ ounces of this arsenic solution. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(37) Took one-fiftieth of an ounce of strychnine and 1½ ounces of nitric acid. Confined it twenty minutes. Residue consisted of a brownish cloud in bottom of generator beneath the limpid liquid. No leaves and only a few Iceryæ were killed.

(38) To residue of above was added three-fourths of an ounce of quicklime. Confined it twenty minutes. Liquid portion of residue brownish; the solid portion bright yellow. No leaves and only a few Iceryæ were killed.

(39) Put about one one-hundred-and-sixtieth of an ounce of strychnine into half an ounce of water and added this to three-fourths of an ounce of quicklime. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(40) Took 1 ounce of mercury, stirred into it a little earth, and added 1 fluid ounce of nitric acid. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(41) To residue of above was added three-fourths of an ounce of quicklime. Confined it twenty minutes. One-half of the leaves, three-fourths of the Iceryæ on upper part, and one-fourth of those on the lower part of the tree were killed.

(42) Dissolved one-sixth of an ounce of arsenic in 2 ounces of muriatic acid. Took 1½ ounces of this solution and one-sixth of an ounce of pure zinc in small pieces. Confined it twenty minutes. No leaves and only a few Iceryæ were killed.

(43) Added half an ounce of nitric acid to the remnant of the arsenic solution of the preceding experiment, and added this to half an ounce of pure zinc. Confined it twenty minutes. Nine-tenths of the leaves and forty-nine fiftieths of the Icerayæ were killed.

(44) Took 1 ounce, by weight, of mercury and 1 fluid ounce of nitric acid. Confined it twenty minutes. One-fourth of the leaves but only a few of the Iceryæ were killed.

(45) Dissolved one-sixth of an ounce of arsenic in 2 ounces of muriatic acid, and added half an ounce of nitric acid. Took 1 ounce of this solution and one-sixth of an ounce of zinc. Confined it twenty minutes. No leaves and only a few Iceryæ were killed.

(46) To residue of above was added three-fourths of an ounce quicklime. Confined it twenty minutes. A few leaves at the top of the tree were killed; about twenty-nine-thirtieths of the Iceryæ on upper three-fourths of the tree and two-thirds of those on the lower fourth were killed.

(47) Took half an ounce of the arsenic solution of experiment 45 and one-twelfth of an ounce of pure zinc. Confined it twenty minutes. Leaves uninjured; one-third of the Iceryæ were killed.

(48) Added one-fourth of an ounce of nitric acid to three-fourths of an ounce of the arsenic solution of experiment 45, and added this to one-sixth of an ounce of pure copper in small pieces. Confined it twenty minutes. Leaves uninjured; one-third of the Iceryæ were killed.

(49) Took 2 ounces of mercury and 1 ounce of nitric acid. Confined it twenty minutes. All of the leaves and about one-third of the Iceryæ were killed.

(50) To residue of above was added three-fourths of an ounce of quicklime. Confined it twenty minutes. A few leaves at top of tree and about two-thirds of the Iceryæ were killed.

(51) Took 1 ounce of mercury and three-fourths of an ounce of nitric acid. Confined it twenty minutes. One-half of the leaves and one-third of the Iceryæ were killed.

(52) Diluted one-fourth of an ounce, by weight, of bromine with 1½ fluid ounces of water, and added this to 2 pieces of phosphorus, each as large as a copper cent. Confined it twenty minutes. All of the leaves and one-third of the Iceryæ were killed.

(53) To residue of above was added three-fourths of an ounce of quicklime. Confined it twenty minutes. Leaves uninjured; one-fifth of the Iceryæ were killed.

(54) Diluted one-eighth of an ounce of bromine with 1½ ounces of water, and added this to a piece of phosphorus the size of a copper cent. Confined it twenty minutes. All of the leaves and one-fifth of the Iceryæ were killed.

(55) Dissolved one-third of an ounce of arsenic in 4 ounces of muriatic acid. Added 2 ounces of this solution to half an ounce of quicklime and one-sixth of an ounce of pure zinc in small pieces. Confined it twenty minutes. Liquid part of residue limpid, and upon this floated a dark-brown, ointment-like substance. One-third of the leaves were killed; found only one living Iceryæ.

(56) To 1 ounce of the arsenic solution of the preceding experiment was added half an ounce of nitric acid and 1 ounce of water; this was then added to one-fourh of an ounce of quicklime and one-sixth of an ounce of pure zinc. Confined it twenty minutes. Five-sixths of the leaves and two-thirds of the Iceryæ were killed.

(57) Added 1 ounce of nitric acid to 1½ ounces of the arsenic solution of experiment 55; this was then added to one-fourth of an ounce of quicklime and half an ounce of mercury. Confined it twenty minutes. Residue light brown. Only a few leaves and two-thirds of the Iceryæ were killed.

(58) Diluted 1 ounce of nitric acid with 1 ounce of water, and added this to one-fourth of an ounce of quicklime and one-fourth of an ounce of mercury. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(59) Put one-seventh of an ounce of naphthaline in 1 ounce of alcohol and let it stand for two days. Diluted half an ounce of this solution with 1 ounce of water, and added it to half an ounce of quicklime; upon adding the water to the colorless alcoholic solution the latter turned milky white. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(60) Dissolved half an ounce of arsenic in 6 ounces of muriatic acid. Added 2 ounces of this solution to half an ounce of quicklime. Confined it twenty minutes. One-sixth of the leaves and nineteen-twentieths of the Iceryæ were killed.

(61) Added 2 ounces of the arsenic solution of the preceding experiment to half an ounce of quicklime and half an ounce of mercury. Confined it twenty minutes. One-third of the leaves were killed; found only two living Iceryæ.

(62) Added 1 ounce of nitric acid to half an ounce of the naphthaline solution of experiment 59. Confined it twenty minutes. The residue was of a yellowish-green color, and had an oily appearance. All of the leaves were killed; found only one living Iceryæ.

(63) To the residue of the above was added three-fourths of an ounce of quicklime. Confined it twenty minutes. One-sixth of the leaves were killed and a few of the Iceryæ.

(64) Same as in experiment 58. Leaves uninjured; only a few of the Iceryæ were killed.

(65) Added half an ounce of nitric acid to 1½ ounces of the arsenic solution of experiment 60, then added this to one-fourth of an ounce of quicklime and the same quantity of mercury. Confined it twenty minutes. Residue brown. One-fourth of the leaves and four-fifths of the Iceryæ were killed.

(66) Added five-sixths of an ounce of the arsenic solution of experiment 60 to half an ounce of quicklime. Confined it twenty minutes. No leaves were killed; found only two living Iceryæ.

(67) Added 1½ ounces of bleaching powder to 1 ounce of methyl alchohol. Confined it twenty minutes. One-eighth of the leaves were killed; nearly all of the Iceryæ on lower part of the tree but only a very few of those on the upper part were killed.

(68) To residue of above was added half an ounce of water and three-fourths of an ounce of quicklime. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(69) Added three-fourths of an ounce of nitric acid to 1 ounce of methyl alcohol. Confined it twenty minutes. Residue dark brown. No leaves nor Iceryæ were killed.

(70) To residue of above was added three-fourths of an ounce of quicklime. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(71) Added three-fourths of an ounce of quicklime to 1 ounce of muriatic acid containing about one-fortieth of an ounce of the oil of tobacco. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(72) Added three-fourths of an ounce of quicklime to 1 ounce of water containing about one-fortieth of an ounce of the oil of tobacco. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(73) Added three-fourths of an ounce of nitric acid to half an ounce of water containing about one-fortieth of an ounce of the oil of tobacco. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(74) To residue of above was added three-fourths of an ounce of quicklime. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(75) Mixed half an ounce of water with 1 ounce of carbon bisulphide, and added it to three-fourths of an ounce of quicklime. Confined it twenty minutes. Leaves uninjured; only a few Iceryæ were killed.

(76) Added three-fourths of an ounce of nitric acid to 1 ounce of carbon bisulphide. Confined it twenty minutes. Leaves uninjured; only a few of the Iceryæ were killed.

(77) To residue of above was added three-fourths of an ounce of quicklime. Confined it twenty minutes. One-eighth of the leaves were killed; found only one living Icerya.

(78) Added 1 ounce of muriatic acid to 1 ounce of carbon bisulphide. Confined it twenty minutes. Leaves uninjured; one-half of the Iceryæ were killed.

(79) To residue of above was added three-fourths of an ounce of quicklime. Confined it twenty minutes. One-half of the leaves on the lower half of the tree were killed; found no living Iceryæ on lower half of the tree, but found several on the upper half, nearly all of those at the very top of the tree being alive.

(80) Same as in experiment 78. Leaves uninjured; one-third of the Iceryæ were killed.

(81) Added residue of above to 1 ounce of quicklime. Confined it twenty minutes. One-half of the leaves on the lower half of the tree were killed; four-fifths of the Iceryæ on the lower half of the tree were killed, but only about one-half of those on the upper half.

(82) Added 1½ ounces of muriatic acid to half an ounce of potassium cyanide. Confined it twenty minutes. Residue of the color of claret wine. Leaves uninjured; found only 3 living Iceryæ.

(83) Added residue of above to 1 ounce of quicklime. Confined it twenty minutes. Liquid part of residue deep green, upon which floated a deep-blue substance. All the leaves on upper third of the tree were killed; found no living Iceryæ.

(84) Added 1½ ounces of water to half an ounce of potassium cyanide. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(85) Added residue of above to 1 ounce of quicklime. Confined it twenty minutes. No leaves and only a few Iceryæ were killed.

(86) Added three-fourths of an ounce of muriatic acid to one-half an ounce of chloroform. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(87) Added residue of above to 1 ounce of quicklime. Confined it twenty minutes. Leaves uninjured; nearly all of the Iceryæ on the lower third of the tree were killed, but nearly all of those on the upper third were alive.

(88) Diluted half an ounce of chloroform with the same quantity of water, and added it to 1 ounce of quicklime. Confined it twenty minutes. No leaves and only a few of the Iceryæ were killed.

(89) Added 1 ounce of muriatic acid to 1 ounce of benzine. Confined it twenty minutes. No leaves and only a few Iceryæ were killed.

(90) Added residue of above to 1 ounce of quicklime. Confined it twenty minutes. No leaves and only a few of the Iceryæ were killed.

(91) Diluted 1 ounce of benzine with half an ounce of water, and added it to 1 ounce of quicklime. Confined it twenty minutes. No leaves nor Iceryæ were killed.

(92) Added 13 ounces of sulphuric acid (density 65°, as ascertained by the hydrometer) to 10 ounces of the best grade of fused potassium cyanide under the tent. Stirred air in tent five minutes with tin blower, then waited ten minutes, and again stirred it for five minutes. Left tent on tree from 3.30 to 4 o'clock p. m.; sun shining brightly. Tree 12 feet high by 10 feet in diameter; bottom of tent resting on ground. One-twelfth of the leaves and nineteen-twentieths of the Iceryæ were killed; fruit uninjured. A slightly larger percentage of the eggs hatched out than in the following experiment.

(93) Added 14 ounces of sulphuric acid to 10 ounces of potassium cyanide and 1 ounce of bicarbonate of soda. Stirred air in tent as before. Left tent on tree from 4.30 to 5 o'clock p. m.; sun shining brightly. A mandarin tree, 12 feet tall. Only a few leaves were killed; fruit uninjured. Forty-nine-fiftieths of the Iceryæ and nearly all of the eggs were killed.

(94) Dissolved 2 ounces of potassium cyanide in 3 pints and 1½ ounces of water. Added 13 ounces of sulphuric acid to 20 ounces of this solution. Stirred air in tent as before. Left tent on tree from 3 to 3.30 o'clock p. m.; sun shining brightly. Tree 12 feet tall. Two-fifths of the leaves, two-thirds of the fruit, and all of the Iceryæ and eggs were killed.

(95) Added 13 ounces of sulphuric acid to 20 ounces of the cyanide solution of the preceding experiment, in which had been stirred 1 ounce of bicarbonate of soda. Stirred air in tent as before. Left tent on tree from 3.50 to 4.20 o'clock p. m.; sun shining. Tree 12 feet tall. After treatment the tent was simply lifted up to allow the gas to escape, after which it was again placed over the tree, and the doorway left partially open; it remained over the tree for a whole week, when it was removed. Fourteen-fifteenths of the leaves, five-sixths of the fruit, and all of the Iceryæ and eggs were killed.

(96) Stirred 4 ounces of water into 11 ounces of bicarbonate of soda, and added it to 11½ ounces of the cyanide solution of experiment 94. To this were added 7½ ounces of sulphuric acid. Stirred air in tent as before. Left tent on tree from 3.05 to 3.35 p. m.; sun shining. Tree 10 feet tall. One-fifteenth of the leaves, thirty-nine-fortieths of the Iceryæ, and nearly all of the eggs were killed.

(97) Poured 3 ounces of arsenic into 16 ounces of muriatic acid, and allowed it to stand a little over a week, then added it to 16 ounces of quicklime under the tent. Stirred air in tent as before. Left tent on tree from 4 to 4.30 p. m.; sun shining. Tree 10 feet tall. No leaves nor Iceryæ were killed.

(98) Stirred 7 ounces of water into 16 ounces of bicarbonate of soda, and added it to 15½ ounces of the cyanide solution of experiment 94; to this was added 11 ounces of sulphuric acid. Stirred air in tent as before. Left tent on tree from 2.50 to 3.20 o'clock p. m.; sun shining. Tree 11 feet tall; a peach tree. Very few of the leaves and nearly all of the Iceryæ were killed.

(99) Boiled 20 ounces of arsenic and the same of bicarbonate of soda in 3 pints of water for one hour. Added 18 ounces of sulphuric acid to 24 ounces of the above solution. Stirred air in tent as before. Left tent on tree from 3.45 to 4.15 o'clock p. m.; sun shining. Tree 10 feet tall. No leaves and only a few Iceryæ were killed.

(100) Stirred 6 ounces of water into 14½ ounces of bicarbonate of soda, and added it to 15½ ounces of the cyanide solution of experiment 94; to this was added 10 ounces of sulphuric acid. Did not stir the air in the tent. Left tent on tree from 3 to 3.30 o'clock p. m.; sun shining. Tree 11 feet tall. One-half of the leaves were killed; found no living Iceryæ.

(101) Stirred 24 ounces of water into 42 ounces of bicarbonate of soda; to this was added 11 ounces of sulphuric acid. Stirred air in tent for five minutes after starting, waited ten minutes and then stirred it again for five minutes. Left tent on tree from 3.55 to 4.25 o'clock p. m.; sun shining. Tree 11 feet tall. No leaves nor Iceryæ were killed; the latter were motionless when the tent was first removed from the tree.

(102) Stirred 12 ounces of water into 31 ounces of bicarbonate of soda, and added it to 15½ ounces of the cyanide solution of experiment 94; to this was added 12 ounces of sulphuric acid. Stirred air in tent as before. Left tent on tree from 2.55 to 3.25 o'clock p. m.; sun shining. Tree 11 feet tall. Very few leaves were killed; found only three living Iceryæ.

(103) Stirred a sufficient quantity of water into 11 ounces of bicarbonate of soda to make it into a thin paste, and added it to 11½ ounces of the cyanide solution of experiment 94; to this was added 7½ ounces of sulphuric acid. Stirred air in tent only five minutes after starting. Left tent on tree from 3.10 to 3.40 o'clock p. m.; sun shining. Tree 10 feet tall. Two-thirds of the leaves, nearly all of the fruit, and all of the Iceryæ were killed.

(104) Stirred a little water into 1 pound of marble dust, and added it to 11½ ounces of the cyanide solution of experiment 94; to this was added 8 ounces of sulphuric acid. Stirred air in tent as in experiment 101. Left tent on tree from 4.05 to 4.35 p. m.; sun shining. Tree 10 feet tall. Only a few of the leaves were killed; found no living Iceryæ.

(105) Added 10 ounces of sulphuric acid to 16 ounces of the cyanide solution of experiment 94, and passed the gas through 24 ounces of sulphuric acid. Stirred air in tent as before. Left tent on tree from 2.45 to 3.15 o'clock p. m.; sun shining. Tree 11 feet tall. Very few of the leaves, none of the fruit, and about forty-nine-fiftieths of the Iceryæ were killed. The density of the sulphuric acid before the gas passed through it was 64½°, as indicated by the hydrometer; after the gas had passed through it its density was found to be 63½°.

(106) Added 11 ounces of sulphuric acid to 16 ounces of the cyanide solution of experiment 94, and passed the gas through 24 ounces of sulphuric acid. Stirred air in tent as before. Left tent on tree from 3.50 to 4.20 o'clock p. m.; sun shining. Tree 11 feet tall. Very few of the leaves and nearly all of the Iceryæ were killed. The acid through which the gas was passed had a density of 63½°, as indicated by the hydrometer.

(107) Added 16 ounces of sulphuric acid to 26 ounces of the cyanide solution of experiment 94, and passed the gas through sulphuric acid. Stirred air in tent as before. Left tent on tree from 3.40 to 4.10 o'clock; sun shining. Tree 11 feet tall. Leaves scarcely affected; found no living Iceryæ. The residue contained acid in great excess.

(108) Dissolved 5 pounds best grade of potassium cyanide in 6 pints of water. I first tried to dissolve it in 4 pints of water, but all of the cyanide was not dissolved after being boiled for 1 hour; I then added 2 pints of water, when all of the cyanide dissolved after being boiled for only a few minutes. Added 16 ounces of sulphuric acid to 30 ounces of the above cyanide solution, and passed the gas through sulphuric acid. Stirred air in tent as before. The tent had been charged with a small quantity of the gas, after which it was opened and allowed to remain on the tree from 11 o'clock a. m. to 10.30 o'clock a. m. of the following day, when it was charged and allowed to remain on the tree for half an hour longer. Tree 11 feet tall. Fourteen-fifteenths of the leaves were killed; found no living Iceryæ.

(109) Added 2 pounds of bicarbonate of soda, made into a thin paste with water, to 24 ounces of the cyanide solution of experiment 108; to this was added 20 ounces of sulphuric acid. Stirred air in tent as before. Left tent on tree from 12.40 to 1.10 o'clock p. m.; sun shining. Tree 11 feet tall. One-sixth of the leaves were killed; found no living Iceryæ.

(110) Sublimed 1 pound of flowers of sulphur, and passed it into the tent. The sulphur was put into an iron vessel having a perforated lid, and this was set on the hot charcoal in the upright furnace of an Acme Fumigator; this fumigator is furnished with a fan-blower, to which I had a tin pipe attached in such a manner that the air was drawn out of the top of the tent and forced into the lower part of the upright furnace, passing by another pipe out of the upper part of the furnace into the lower part of the tent. The sulphur vapor was passed into the tent in fifteen minutes, after which the tent was removed from the tree. Tree 10 feet tall. Three-fifths of the leaves, all of the fruit, and four-fifths of the Iceryæ were killed.

(111) Sublimed half a pound of sulphur, as in the preceding experiment, and passed it through a second horizontal furnace, in the form of a cylinder, about 18 inches long and 6 inches in diameter, filled with red-hot charcoal. Passed it into the tent in ten minutes, and left tent on tree ten minutes longer. Tree 10 feet tall. All of the leaves and fruit, many of the twigs, and two-thirds of the Iceryæ were killed.

(112) Sublimed half a pound of sulphur and passed it over hot charcoal, as in the preceding experiment. Passed it into the tent in eight minutes, and left tent on the tree twenty-two minutes longer. Tree 10 feet tall. Five-sixths of the leaves, two-thirds of the fruit, a few of the twigs, and one-half of the Iceryæ were killed.

(113) Sublimed 6 ounces of sulphur and passed the vapor over hot charcoal, as in experiment 111. Passed it into the tent in one hour, and then removed the tent. Tree 10 feet tall. Eleven-twelfths of the leaves, all of the fruit, and many of the twigs were killed; found no living Iceryæ.

(114) Sublimed 2 ounces of sulphur and passed the vapor over hot charcoal and into the tent. The sulphur was put into a tight iron vessel, through the lid of which passed a small pipe leading to the pipe by which a Cummings' blower was attached to the horizontal furnace containing the charcoal; the sulphur was sublimed by the use of a small kerosene stove placed beneath the vessel containing the sulphur, and as the vapor from the sulphur rose it was blown over the hot charcoal into the tent. Passed the vapor into the tent in forty minutes and left the tent on the tree five minutes longer. Tree 10 feet tall. Seven-eighths of the leaves, all of the fruit, and many of the twigs were killed; found no living Iceryæ.

(115) Passed the vapor of 2 ounces of sulphur over hot charcoal and into the tent. The furnace was the same as that described in experiment 111, except that it was placed vertically and that its length had been increased to 3 feet; the vessel containing the sulphur was led into one side of the furnace, and to its lower end was attached a piece of gas-pipe leading into the furnace at a point about one-fourth of the height of the furnace. The sulphur placed in this vessel soon melted and ran down the gas-pipe and into the furnace, where it was vaporized and its vapor blown over the hot charcoal and into the tent through a pipe passing out of the upper end of the furnace and leading into the lower part of the tent. The gas-pipe below the vessel containing the sulphur was provided with a stop-cock, to regulate the flow of the melted sulphur. The sulphur was run into the furnace in twenty minutes, and the tent was left on the tree five minutes longer. Tree 10 feet tall. No leaves and only a few Iceryæ were killed.

(116) Run 2 ounces of sulphur into furnace in ten minutes, and allowed the vapor to pass over the hot charcoal and into the tent of its own accord. After running the sulphur into the furnace for five minutes the air in the tent was stirred with a Cumming's blower, which drew the air out at the top of the tent and forced it in at the bottom. Left tent on tree half an hour. Tree 10 feet tall. Furnace same as used in preceding experiment. No leaves and only a few Iceryæ were killed.

(117) Run 2 ounces of sulphur into furnace in ten minutes, then stirred air in tent for five minutes, and left tent on tree half an hour longer. The sulphur vapor was allowed to pass over the hot charcoal and into the tent of its own accord. Furnace same as used in preceding experiment. Tree 10 feet tall. No leaves and only a few Iceryæ were killed.

(118) Run 3 ounces of sulphur into furnace in fifteen minutes, then stirred air in tent for five minutes, and left tent on tree twenty minutes longer. Furnace as in preceding experiment; sulphur vapor passed into tent of its own accord. Tree 10 feet tall. Only a few of the leaves and about one-eighth of the Iceryæ were killed.

(119) Run 5 ounces of sulphur into furnace, and allowed the vapor to pass into the tent of its own accord. After the melted sulphur had run into the furnace for eight minutes its flow was stopped, the pipes leading into the tent were disconnected, and the blower was attached to the furnace, and the latter was fired up for

four minutes, after which the pipes were again connected, and the rest of the sulphur run into the furnace in six minutes; the air in the tent was then stirred for five minutes. Tent left on tree fifty minutes. Only a few of the leaves and Iceryæ were killed.

(120) Run 20 ounces of sulphur into the furnace in twenty-four minutes, and allowed the vapor to pass into the tent of its own accord. After the sulphur had been running into the furnace for eight minutes its flow was stopped, the pipes disconnected, and the furnace fired up for two minutes; and this was repeated until all of the sulphur had been run into the furnace, after which the air in the tent was stirred for five minutes. Left tent on tree for one hour. Tree 10 feet tall. No leaves and only a few Iceryæ were killed.

(121) Run 5 ounces of sulphur into the tent in twenty-five minutes. The furnace was fired up after the sulphur had been running into it for five minutes, and this was repeated until all of the sulphur had passed into the furnace, after which the air in the tent was stirred for five minutes. Left tent on tree one hour. Tree 10 feet tall. No leaves and only a few Iceryæ were killed.

(122) Run 16 ounces of sulphur into furnace in twenty-five minutes, then stirred air in tent for five minutes. The furnace consisted of a piece of terra-cotta pipe, 3 feet long and 8 inches in diameter; a hole was made through it near the bottom by which to light the charcoal in the furnace, and there were four other holes along one side of the furnace for the purpose of firing up the latter, which was accomplished by the use of a Cummings' blower. The entire furnace was inclosed in a sheet iron to which the blower was attached, and a pipe led from the top of the furnace into the bottom of the tent; the sulphur was inserted in a piece of gas-pipe that passed to the inside of the furnace. Left tent on tree one hour. Tree 10 feet tall. The bisulphide was allowed to pass into the tent of its own accord. No leaves and about one-sixth of the Iceryæ were killed.

(123) Inserted $1\frac{3}{4}$ pounds of sulphur into furnace in forty minutes, inserting much of it through the hole in the furnace by which the charcoal is lighted; stirred air in tent almost continuously during the time that the sulphur was being inserted into the furnace; the bisulphide was allowed to pass into the tent of its own accord. Left tent on tree one hour and a half; disconnected furnace from tent half an hour before removing the latter from the tree. Leaves slightly injured; only a few Iceryæ were killed.

(124) Inserted $1\frac{1}{2}$ pounds carbonate of ammonium in lower part of furnace in thirty minutes, allowing the vapor to pass over the hot charcoal and into the tent of its own accord. After inserting the ammonium the air in the tent was stirred for ten minutes. Left tent on tree for one hour; disconnected furnace from tent fifteen minutes before removing latter from tree. Tree 10 feet tall. No leaves and only a few Iceryæ were killed. A whitish deposit remained upon the leaves.

(125) Inserted $2\frac{3}{4}$ pounds of sulphur in lower part of furnace in thirty-five minutes, during which time the air in the tent was stirred almost continuously. Left tent on tree one hour; disconnected furnace from tent five minutes before removing latter from the tree. Tree 10 feet tall. No leaves and only a few Iceryæ were killed.

(126) Inserted in lower part of furnace 3 pounds of sulphur in packages of 8 ounces each at intervals of six minutes apart; during this time the air in the tent was stirred occasionally. Left tent on tree one hour; disconnected furnace from tent five minutes before removing the latter from the tree. Tree 10 feet tall. Leaves slightly injured; only a few Iceryæ were killed.

(127) Inserted 5 pounds of sulphur into lower part of furnace in 10-ounce packages at intervals of six minutes apart. After the lapse of thirty minutes from starting the air in the tent was stirred for ten minutes. Left tent on tree for one hour and a half; disconnected the furnace from the tent five minutes before removing the latter. Tree 10 feet tall. One-third of the leaves and three-fourths of the Iceryæ were killed.

(128) Put $3\frac{7}{8}$ pounds of refuse tobacco stems on top of the red hot charcoal in the furnace and allowed the vapor to pass into the tent for fifteen minutes; then blew a blast of air through the furnace for five minutes, without disconnecting the furnace from the tent, after which the vapor was allowed to pass into the tent of its own accord, and the air in the tent was stirred for ten minutes. Left tent on tree one hour; disconnected the furnace from the tent five minutes before the latter was removed from the tree. Tree 10 feet tall. Leaves uninjured; found no living Iceryæ.

(129) Inserted $3\frac{1}{4}$ pounds of sulphur into lower part of furnace in packages of $10\frac{2}{5}$ ounces each, a package being inserted at the end of every twelve minutes. After all of the sulphur had been inserted the air in the tent was stirred for ten minutes. Left tent on tree one hour and a half; disconnected furnace from tent five minutes

before removing the latter from the tree. Tree 10 feet tall. Leaves uninjured; only a few Iceryæ were killed.

(130) Put 1 pound of the best grade of fused potassium cyanide on top of the red-hot charcoal in the furnace and allowed the vapors to pass into the tent. After the lapse of ten minutes the air in the tent was stirred for ten minutes. Left tent on tree half an hour; disconnected furnace from tent five minutes before removing the latter from the tree. Tree 10 feet tall. Neither leaves nor the Iceryæ were injured.

INDEX TO EXPERIMENTS.

Following is an alphabetical list of the substances and combinations used in the preceding experiments; the numbers are those of the different experiments. I have prefixed an asterisk (*) to those which proved fatal to at least one-sixfh of the Iceryæ:

REPORT ON EXPERIMENTS AGAINST SCALE-INSECTS.

By ALBERT KOEBELE, *Special Agent.*

LETTER OF SUBMITTAL.

ALAMEDA, CAL., *December* 26, 1887.

SIR: I herewith submit report of continued experiments with kerosene emulsion and resin compound upon various scales, plant-lice, etc., made at Alameda during 1887, according to your instructions.

Very respectfully,

ALBERT KOEBELE.

Prof. C. V. RILEY,
U. S. Entomologist.

THE VALUE OF ARSENIC AS AN ADDITION TO THE KEROSENE EMULSION.

In the main I followed your suggestion while here in April last, in preparing the kerosene emulsion, viz, to emulsify with resin compound, and use arsenic acid in addition. I am glad that your hopes in this wash are verified. In every instance where your proposed arsenic acid was added either to emulsified kerosene or resin compound there has been a complete extermination of the scales.

At first too much of the arsenic acid was used, resulting in more or less injury to trees treated, particularly so in weak washes.

The best results in preparing the emulsion were obtained by taking 1 part of the kerosene to 1 part of lukewarm resin compound. Thus I obtained 2 gallons of emulsion in less than three minutes that did not show any trace of separation before the end of twenty-four hours. The result would have been not quite so good if the resin compound had been used hot in emulsifying, and still less so if 2 parts of kerosene h d been used to 1 of resin compound; but still this last will make a very good emulsion if prepared properly, which is easily done. It has the good quality of spreading instantly over the leaves if sprayed with diluent, as well as do soap washes. None of the experiments made during dry weather with this emulsion alone, *i. e.*, without the additional arsenic acid, were appreciably effective. The evaporation was very rapid and in ten minutes after application no trace of the wash could be seen.

In addition I include results of various experiments with resin compound, especially upon Aphidæ, which it affects admirably; and, at the same time, a wash can be prepared which will destroy all Aphids and not injure the larvæ of Syrphus flies nor prevent the parasites from hatching from the infested Aphids.

Experiment 158.*—Pure kerosene.

Pure kerosene on *Aspidiotus rapax* on Pear. Applied with rag February 22, on small and sickly tree, with only one living branch. February 27 a heavy shower washed off a number of scales which were loosening. May 5, all the dormant buds starting out, trees growing vigorously; not a living scale could be found.

Experiment 165.—Kerosene emulsion.

Prepared of half lukewarm resin compound† and half kerosene; worked for two minutes with pump. This formed a good emulsion. In twenty-four hours oil began to appear on top, and on the fifth day three-eighths of an inch of oil had collected on top, in bottle with 4 inches of emulsion reserved.

Emulsion, 1 part; water, 10 parts. Applied July 27, on *Aspidiotus rapax* on Pear. Cloudy day and a little rain the following night. Examined August 1 and 19; no appreciable result; only small part of young scales were destroyed; new scales forming numerously.

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*The numbering of these experiments is consecutive with the series published in the annual report for 1886, pp. 560 to 572.

†Dissolve 3 pounds of sal soda and 4 pounds of resin in 3 pints of water above fire; when properly dissolved add water slowly, while boiling, to make 36 pints of compound.

Experiment 166.—Kerosene emulsion 165.

One part emulsion to 20 parts of water. Applied July 27. Destroyed but few of the young scales; tree full of newly-formed scales August 19.

Experiment 167.—Kerosene emulsion.

Made of kerosene, 2 parts; resin compound, 1 part. Prepared cold by working with pump for 2 minutes. This will make a good emulsion, but separates sooner than 165.

One part of the emulsion to 8 parts of water were applied August 4 on lemon tree full of *Lecanium hesperidum.* About three-fourths of the scales were destroyed, and they were soon on the increase again.

Experiment 169.—Kerosene emulsion 167.

One part of the emulsion to 5 parts of water. Applied August 27, on *Aspidiotus sp.*, on Currant, *A. rapax* and *Mytilaspis pomorum* on Apple, which was also badly infested with Wooly Aphis (*Schizoneura lanigera*) and Red Spider. This destroyed only about half of the scales on Currant (which are exceedingly hard to kill), and where well protected the effects were not visible. Result on *A. rapax* on Apple much better, but not all died. Of *M. pomorum* only young scales were destroyed. Wooly Aphis and Red Spider were killed, but the eggs of the latter were not affected. Not the slightest injury to plants visible.

Experiment 170.—Kerosene emulsion 167.

One part of the emulsion to 10 parts of water. Applied August 27, on *Aspidiotus sp.*, on Currant, *A rapax* on Apple and Cherry.

September 1, about one-third of the scales dead on Currant; found many dead young and eggs under mother scales; plant full of newly-hatched young. Of *A. rapax*, on Apple and Cherry, all scales dead except an occasional one under mother scale; a few gravid females living. October 7, only a small number of scales living on Apple and Cherry, but numerous on Currant. Plant not at all injured.

Experiment 171.—Kerosene emulsion 167.

Emulsion, 1 part; water, 15 parts. Applied August 27, on *Aspidiotus sp.*, on Currant and *A. rapax* on Cherry. This scarcely affected the scales.

Experiment 172.—Kerosene emulsion 165.

Emulsion, 1 part; water, 4 parts. Applied August 27, on *Aspidiotus sp.*, on Currant and *A. rapax* on Plum in bearing. September 1, about four-fifths of the scales on Currant dead, and none living could be found on Plum. Plants show no trace of wash. October 7, scales on Currant increasing; found one living on upper branch of Plum. November 28, scales very numerous on Currant again.

Experiment 173.—Kerosene emulsion 165.

Emulsion, 1 part; water, 8 parts. Applied August 27, on *Aspidiotus sp.*, on Currant, and *A. rapax* on Peach. September 1, scales and eggs, where not well protected, all dead on Currant; on Peach about four-fifths destroyed. This tree was covered with red spiders, nearly all of which were destroyed by this wash. October 7, scales increasing on both plants. November 28, scales numerous again, but more so on Currant.

Experiment 174.—Kerosene emulsion 165.

Emulsion, 1 part; water, 12 parts. Applied August 27, on *Aspidiotus sp.*, on Currant. The result was nearly as good as in 173.

Experiment 188.—Kerosene emulsion 167.

This emulsion was prepared with hot resin compound and could not be united properly; part of free oil floating on top. One-half emulsion to one-half water. Applied September 13, on a strong young apple tree in bearing; also on Cherry. September 21, all the fruit on Apple spotted; leaves on sunny side partly burned; eggs of *M. pomorum* not affected, nor eggs of red spider; tips of leaves on Cherry black on south side; otherwise no injury to this tree. October 7, apple tree in good condition; some of the leaves on south side partly dry; wash on Cherry not visible; no injury was done here. November 22, apple tree had made few new growths on one branch and had bloomed on this part; eggs of *M. pomorum* not yet hatched; all in good condition.

Experiment 177.—Kerosene emulsion 167 with arsenic, of which 1 pound in 55 gallons wash.

One-half pound of arsenic and one-half pound sal soda boiled in one-half gallon water until dissolved, and this diluted in 20 pints of water.

Experiment 178.—Kerosene emulsion 167 with arsenic, of which 1 pound in 55 gallons wash.

Emulsion, 1 part; water, 15 parts. Applied August 30, on *A. rapax* on Pear. September 1, leaves spotted, turning brown. September 7, all leaves dead and dry; bark not injured except on few smallest twigs; scales all killed. October 7, tree bringing forth new shoots all over; some in blossom; all buds not dead growing. November 22, new shoots of 8 inches in length had formed; fruit did not set; tree in good condition; still growing. December 17, tree fresh and green; no scales whatever.

Experiment 179.—Kerosene emulsion 167 with arsenic, of which 1 pound to 52½ gallons wash.

Emulsion, 1 part; water, 20 parts. Applied August 30, on *Aspidiotus sp.*, on Currant, and *A. rapax* on Cherry. September 7, leaves nearly dry and falling off; scales appear to be dead, but still have their natural color. October 7, all scales and eggs dead; young shoots forming on Currant. November 22, currant plant still growing; some blossoms and young fruit; no scales. December 17, no scales; a few of the berries have become mature, but are small.

Experiment 180.—Kerosene emulsion with arsenic, of which 1 pound to 55 gallons wash.

Emulsion, 1 part; water, 2 parts. Applied August 30, on *Aspidiotus sp.*, on Currant, *A. rapax* and *M. pomorum* on Apple. September 7, scales on Currant, where in thick layers, not all dead; a few eggs and newly-hatched young found; *A. rapax* on Apple not all dead; gravid females and eggs of *M. pomorum* not affected; leaves of Apple dry and those on Currant nearly so. October 7, scales on Currant all dry; plant growing; *A. rapax* on Apple all dead; eggs of *M. pomorum* in good condition. November 22, no living scales on Currant, this still growing; eggs of *M. pomorum* still intact.

Experiment 181.—Kerosene emulsion 165 with arsenic, of which 1 pound in 55 gallons wash.

Emulsion, 1 part; water, 15 parts. Applied August 30, on *Aspidiotus* on Currant. September 7, leaves of plant all dry; a few of the scales still living; also eggs and newly-hatched young found. October 7, all scales dead; plant in good condition. November 22, no living scales can be found. December 17, no living scales on plant.

EXPERIMENTS WITH RESIN COMPOUND AND ARSENIC.

Experiment 185.—Resin compound and arsenic, of which 1 pound in 85 gallons wash.

Compound, 1 part; water, 16 parts. Applied September 2, on *Lecanium hesperidum* on Orange.* September 7, most of the young and tender shoots destroyed; a few leaves falling; scales appear to be dead. September 13, scales all dead; leaves still falling, only few remaining on tree. November 22, no living scales; tree growing; fall of young shoots, but very few of the old leaves remaining. December 17, found four young scales, which evidently have come from neighboring trees; tree in good condition again; still growing.

Experiment 186.—Resin compound and arsenic, of which 1 pound in 90 gallons wash.

Compound, 1 part; water, 8 parts. Applied September 2, on *L. hesperidum* on Orange. September 7, scales dead; found a few living young under mother scale; a few leaves falling. September 13, all scales dead; about half of the leaves have fallen. October 7, no living scales. November 22, about one-third of the leaves remaining; tree otherwise in good condition. December 17, tree in good condition; no living scales.

* All orange trees experimented on were in poor condition, received no water during summer, and leaves were curled.

Experiment 187.—Resin compound and arsenic, of which 1 pound in 100 gallons wash.

Compound, 1 part; water, 4 parts. Applied September 2, on *L. hesperidum* on Orange. September 7, scales all dead. September 13, no living scales; about one-fourth of the leaves have fallen. October 7, tree in good condition; not injured beyond the loss of a few leaves; all scales, lichens, and fungus destroyed. November 22, tree in very good condition; no living scales.

Experiment 189.—Resin compound and arsenic, of which 1 pound in 170 gallons wash.

Compound, 1 part; water, 16 parts. Applied September 13, on *L. hesperidum* on Orange. October 7, many scales still living; nearly half of the leaves have fallen. November 22, all scales dead; tree in good condition. December 17, no living scales on tree.

Experiment 190.—Resin compound and arsenic, of which 1 pound in 300 gallons wash.

Compound, 1 part; water, 4 parts. Applied September 13, on *L. hesperidum* on Orange. September 21, scales nearly all dry; no leaves whatever have fallen. October 7, scales all dried up; no leaves have fallen. November 22, no scales on tree, which is in very good condition.

EXPERIMENTS WITH RESIN COMPOUND.

The strongest application of this was made on Pear and Plum, infested with *A. rapax*, August 27; three parts of the compound to four of water (Experiment 176). September 7, all traces of wash had disappeared, not injuring the foliage of Plum. The leaves of Pear were very brittle for the first few days, and some tips of older leaves turned black, but none came off, and otherwise no injury was done. An occasional living scale was found October 7.

One part of the compound to two of water. Applied February 28, on *A. rapax* on Pear (Experiment 160). Rain fell for two days following, and the result, perhaps, was not as good as it would otherwise have been. A careful examination on March 8 showed that a large part of the eggs had been destroyed, also all the young and many of the older scales. On this tree they did not increase, and November 21 hardly any living scales could be found. Other experiments were made of the same strength, on *Aspidiotus sp.*, on Currant and *A. rapax* on Pear, August 27 (Experiment 175). All but a few gravid females were dest oyed on Pear, and very few remained on such places where they had been in thick layers on Currant. October 7 a few young scales were found on both plants; but hardly any were living November 22. The wash disappeared in ten days, leaving the trees in good condition; no leaves fell.

Three parts of compound to eight of water was applied on Orange, thickly infested with *Lecanium hesperidum*, September 2 (Experiment 184). In five days after application no living scales could be found, and none on November 22. The tree was not at all affected by the wash.

One part of compound to four of water applied on Pear, with *A. rapax*, February 28 (Experiment 159), destroyed all the smaller and part of the older scales, but none after the scales were increasing again. The same strength was also applied on *Diaspis rosæ* on Rose, March 8 (Experiment 162). This effectively cleared the plant of scales. And again, on *L. hesperidum* on Orange, September 2 (Experiment 183). All scales were dead September 7, and none living could be found November 22.

One part of compound to eight of water, on *L. hesperidum* on Orange, September 2 (Experiment 182), destroyed nearly all scales, but many living young were found under mother scales September 7; only very few living scales were found on trees September 13 and October 7; but on November 22 the tree was covered with scales again.

Other experiments of this strength were made and may be worthy of mention. On *L. oleæ* on Orange and on several peach trees in full blossom, infested with the *Lecanium*, bred from Oak (*Q. agrifolia*); here also many of the scales survived; the trees subsequently were loaded with fruit, as well as those not treated.

EXPERIMENTS ON APHIDIDÆ WITH RESIN COMPOUND.

The Wooly Aphis (*Schizoneura lanigera*), the Cabbage Aphis (*Aphis brassicæ*), the Plum Aphis (*Aphis pruni*), and Aphis on Rose (*Siphonophora rosæ*). Two experiments were made at Berkeley on the Wooly Aphis, in conjunction with Messrs. Klee and McLennan. One and three parts of the compound were used to eight of water.

Owing to imperfect spraying only the last did effective work. The leaves of the trees were falling at the time of spraying, and the effect of the solution, especially on tree where three to eight parts of wash were applied, was very noticeable, as the first tree lost about half, while the second lost nearly all its leaves. On my visit to the place a month later, however, there was little difference in the trees treated and others infested with Wooly Aphis, for these also began to lose their leaves about two weeks after, as I was informed by Mr. McLennan, the gardener, who is a very careful observer. Mr. Klee recommends this wash in the proportion of 1¼ pints compound to one gallon water.*

I have made numerous other experiments and always had complete success in killing this insect with one part compound to eight parts of water. With this proportion also those on root which were reached were killed. I would recommend the same, *i. e.*, one part of the compound to six parts of water, on Wooly Aphis. On the other hand, the Plum Aphis, Cabbage Aphis, etc., are much easier to kill; only one part of compound to eight of water was used in experiment at Berkeley (August 10) on Plum Aphis, and none were living on examination August 17. At this strength the Aphis will die instantly and will not even be able to move a leg if once wet. I have killed them successfully even with a wash as low as one part of the compound to sixteen parts of water; and would recommend one part of the compound to twelve parts of water, for Plum Aphis, Aphis on Rose, etc. At this strength it may be safely used on any garden and even on the most tender hot-house plants, without the slightest injury to plants themselves. It should be used somewhat stronger on the Cabbage Aphis. One part of the compound to eight parts of water will be found effectual. At this strength it was found that the larvæ of Syrphus flies were not injured by wash, nor were the parasites which infested the Aphis in any way affected, providing the skin of the Aphis was dry when sprayed.

A lot of House Flies (*Musca domestica*) which had concentrated out of doors were sprayed with this solution and died almost instantly. A large Flesh Fly (*Sarcophaga*) thrown into a weak solution (1 to 16), taken out and set on board, never moved its legs again. Fifteen minutes later, slight convulsive movements were noticed on under side of body, and soon after all life was extinct. A Codling Moth (*Carpocapsa pomonella*), sprayed with a solution of 1 to 8, was dead in nine minutes. Cut Worms (larvæ of *Agrotis saucia*), dipped in this mixture were not affected.

It will be of interest to note that while in Los Angeles in April, 1887, the following labels on trees treated for Red Scale (*A. aurantii*) were still present: "Experiments with resin soap 127, 147, and 149." † All these trees were free from Red Scale and *L. oleæ*, but full of Icerya. "Experiments with resin compound 133 and 156." No Red Scales could be found on these trees, but *L. oleæ* was numerous on tree of experiment 133. Both trees were badly infested with Icerya.

REPORT ON THE SEASON'S OBSERVATIONS, AND ESPECIALLY UPON CORN INSECTS.

By F. M. WEBSTER, *Special Agent.*

LA FAYETTE, IND., *November* 1, 1887.

SIR: I herewith transmit my annual report for the year 1887 of work and observations made under your direction.

Stationed in the Southern States during spring and much of the summer, working under your direction, and upon an entirely different class of insects from those affecting field crops, has prevented me from accomplishing much in the way of investigating the habits of such species as affect our cereal grains. For this reason, I have brought together the results of a considerable number of observations in various parts of the West and Southwest relating to insects affecting Indian corn.

Under head of "*Memoranda*" I have included a number of facts obtained, which, though not properly coming under the head of corn insects, are considered of sufficient value to warrant publication.

Books and collections of insects having been inaccessible to me much of the time, I have in such cases relied upon yourself and assistants for determination of species, without regard to my own ability to determine them myself.

Respectfully,

F. M. WEBSTER.

DR. C. V. RILEY,
U. S. Entomologist.

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* Pacific Rural Press, December 17, 1887, p. 488.

† See Rep. Entom. Dept. Agr., 1886, pp. 571, 572.

THE TWELVE-SPOTTED DIABROTICA.

(*Diabrotica 12-punctata.*)

While in the South during the spring of 1886 we frequently heard of fields of young corn being seriously injured, during some seasons, by a small white worm which attacked the roots, usually during April. From the description given us of the pest and its manner of attacking the plants, we first thought it might be the larva of *D. longicornis*, as the habitat of that species is known to extend southward to Central America.

On April 12 of the present year we were enabled to solve the problem by finding considerable numbers of these larvæ in a field of corn in Tensas Parish, La., where they were working considerable mischief by killing the young plants. As observed by us, their mode of attack differed from that of their northern congener in that they did not appear to attack the fibrous roots or bury themselves in longitudinal channels excavated in the larger roots. On the contrary, they burrowed directly into the plants at or near the upper whorl of roots, which almost invariably resulted in the death of the plant. These larvæ were much more active than those of *longicornis*, and on being disturbed would make their way out of their burrows and attempt to escape by crawling slowly into crevices in the soil, or if it were finely pulverized they would work their way down into it out of sight. Often several individuals, varying greatly in size, would be found about a single plant. On the 20th of same month, in another field, we found the larvæ much more numerous and the crop injured fully 75 per cent. Plants here, 6 to 8 inches high, were withering up and discoloring. Both of these fields had produced cotton the preceding year.

The adult beetles were frequently seen before we observed the larvæ, but they were not abundant about the plants in the corn-fields, being usually on the yellow blossoms of a species of Aster which springs up in cultivated grounds early in the spring in great abundance. No pupæ were found, although careful search was made for them. We have elsewhere shown that the adult insect attacks leaves of young corn in Indiana.*

THE CORN PLANT-LOUSE.

(*Rhopalosiphum maidis.*)

So far as we are aware, this species is not recorded as injuring corn in any of the Gulf States. Considerable damage, however, is done by the root form in both Louisiana and Mississippi, and we observed the aërial form also in great abundance during June and July of the present year in both of these States.

In October, 1885, we transferred some volunteer plants of corn from the field of fall wheat, where they grew, to some breeding-cages. The plants were thickly populated with winged females, and these were carefully secured with the plants, both being subjected to the same conditions which would have influenced them had they remained in the field, except that the ants in attendance were excluded. On May 8, 1886, corn was planted in these cages and grew therein till after the 15th of June without a single individual of either root or aërial form being on or about the plants, and they were then thrown out.

In the meantime corn had been planted indoors in pots, and on June 24 these were placed in a field where serious injury was being done by the root form of the Corn Aphis. The pots were buried in the earth between the rows until the soil within was on a level with, and not obstructed in the least by, the tops of the pots, from the surface of the ground. Several hills seriously infested were pulled up in the vicinity of these pots, thereby exposing both roots and plant-lice to the sun.

The next day the ants were burrowing about the plants in the pots, and a few days later the roots were well stocked with lice, many of them being full-grown. Besides this we had observed ants with lice in their mouths over a yard distant from the hills which had been pulled up, thereby indicating that the bereft were supplied with homes on the neighboring hills as well as on the potted plants.

Grasses and other plants were examined during the autumn, but no distinguishable corn-plant lice were obtainable.

The present season we were absent from home from the middle of March until after the 20th of May. On the 27th of this month, however, we found winged, viviparous females on the roots of corn in a field planted on the 18th instant. A thorough search revealed the fact that the wingless lice were all very small. A heavy rain had fallen on the 23d, and it was only where fresh mounds thrown up

*Indiana Agricultural Report, 1885, p. 198.

by ants were observed that the roots were found tenanted, thus indicating, as did the size of the young lice, that these winged females had appeared on the roots within the preceding four days. The most careful search failed to reveal the origin of these winged lice, as no ants were observed transporting them about, although the latter were very busily engaged in running up and down over the young corn. If, however, a louse were placed on the corn, it was soon found and at once transported to a gallery about a hill of corn. The winged females were not always on the roots of the corn, by any means, but often on the stem, and in one instance a female was observed on a root of grass (*Setaria glauca*) giving birth to her young. Even in this case she was in a gallery surrounded by ants, who doubtless removed her progeny to other quarters.

These observations led me to conclude that the Corn Plant-louse does not live over winter in the fields, nor are the eggs deposited about the corn in the fall, but that they are deposited about the roots of some other plant, most likely one of the grasses. These eggs develop a wingless brood, probably, from which the winged females which first appear in the corn-fields originate. These in turn throw off a wingless brood, and these again a winged brood, thus alternating from one to the other. Also that ants, of which three species attend these plant-lice, viz, *Lasius flavus*, *Formica schaufussii*, and *F. fusca*, are not in the least responsible for their distribution over the fields, although the protection which they afford them greatly increases their numbers and the amount of injury done in the corn-fields.

During June, 1886, a number of experiments were made to test the immediate effect of fertilizers, including salt, upon the lice, and also to learn if the ants could be induced thereby to abandon or remove their favorites to other plants.

The substances used were two commercial fertilizers, Bunner bone dust and bone guano, barn-yard manure, and common salt. A double experiment was made with each. The first two substances were applied (1) by scattering a table-spoonful on the surface of the ground about the plant and sprinkling with water sufficient to at once wash it into the soil, and (2) by drawing the earth away from the roots, scattering the same amount of fertilizer about the roots, then replacing the earth and sprinkling the surface less thoroughly than with the first. The barn-yard manure was well-rotted and a quantity sufficient to fill a pint measure was used in the same way. The salt was used like the manufactured fertilizers.

The result, a week after, was that the lice were still about the roots in every case, and except where salt was used, they were found in the midst of the substances applied. The salt only drove them from one portion of the roots to another. Sand dampened with kerosene was applied in the same way, the surface application having no effect, while that placed about the roots had the same effect as the salt.

That proper fertilizers applied to the soil are a general preventive was clearly proven by the appearance of the crop on a series of eighteen plots, on the University farm. These plots were located side by side and numbered 1 to 18. All had produced corn for the six previous crops, those plots of even numbers not having been fertilized during that time. Plots 1, 7, 13 had, three and again two years previous, received applications of gas-lime; plots 3, 9, 15 had received applications of superphosphates during the same years, while plots 5, 11, 17 had received similar treatment with barn-yard manure. The result, up to July, 1886, was that the corn on all plots except those fertilized by barn-yard manure was small and uneven in growth, while on plots 5, 11, 17 the plants were fully a third larger, more thrifty, and far less uneven in height. In fact, these plots could be distinguished from any of the others at a distance from the field. It was unfortunate that the experiments being carried on forbade any examinations of the roots, in order to estimate the relative number of plant-lice inhabiting each series of plots.

CORN BILL-BUGS.

(*Sphenophorus sculptilis.*)

On June 9 of present year, J. B. Lutz, of Wea, Tippecanoe County, Ind., informed us that ants were destroying his corn; that he had planted one of his fields three times, and each time the corn had been destroyed after it came up. Feeling certain our friend was laboring under a mistake, we visited his field on the 13th instant and found the depredator to be an old offender, but with few exceptions it had not been observed injuring corn in the Western States. Hence it was to us a rather unexpected appearance here in Indiana.

We found quite a number of the beetles engaged in puncturing the plants just below the surface of the ground. The result of this puncture was not, in all cases, the destroying of the plant, although practically the outcome, so far as the crop was concerned, was the same, for instead of a single stalk many laterals or suckers were

put forth from the same roots, and often one sheath covering all at base. The base of this mass of suckers had the appearance of having been wounded and scarified, while the leaves were riddled with holes arranged transversely across the leaf from the puncture of the insect before the leaf had become unrolled. Besides, the leaves were ragged and gnarled, and often aborted.

We had observed the same feature in a corn-field in Tensas Parish, La., in April, but in that instance had supposed that the abnormal growth was due to the work of the larvæ of *Diabrotica*. This, indeed, might have been the case, as both puncture the stem at nearly the same place. Since observing the same feature in Mr. Lutz's field, we are inclined to suspect that some species of *Sphenophorus* might have been at work in the Louisiana field before we saw it, although we found none of the adults there. Still, *D. 12-punctata* is very common in the Northern States, and it will not be surprising if we hear of its work before long.

We found no larvæ or pupæ in Mr. Lutz's field, and as we soon afterwards returned to the South, had no opportunity of again examining it. Either through the effect of the beetles or dry weather, or both, the crop proved a failure. Only the low portion of the field, which comprised about 20 acres, was affected by *Sphenophorus*, the higher parts being uninjured.

MYOCHROUS DENTICOLLIS.

The adult beetles were observed in considerable numbers in fields of young corn in Louisiana during April of the present year. They were found in the soil about the stems of the plants, at or near the surface of the ground, and attack the young corn by gnawing the outside of the stems, but not, so far as we observed, cutting them off or climbing over the leaves. No serious injury was noticed, but the species is a common one, both North and South, although we had never observed it in corn-fields before.

FLEA-BEETLES.

(*Chætocnema confinis* and *Psylliodes interstitialis*.)

The first of these species was observed in Tensas Parish, La., early in April of the present year, where the adults were engaged in eating out the parenchyma from the young corn leaves, appearing to injure the plants considerably, although not permanently. During August these beetles affected young wheat at La Fayette, Ind., in a similar manner.

On June 21 both of these species were observed on corn in Pike County, Ind., in great numbers, the *Psylliodes* predominating. Here the *Chætocnema* followed the same method of attack on the leaves of the plants, but did not appear to select either the smaller or younger plants nor the more tender foliage, but was, if anything, more abundant on the lower than the upper leaves.

The *Psylliodes* worked in precisely the same manner, and on the lower leaves almost exclusively. These did not eat holes in the leaves at all, but seemed to gnaw out the parenchyma from beneath, leaving the upper epidermis and the longitudinal veins intact. Had the beetles desired more tender food, it could have been found in a small plot of much later corn only a few yards distant. This, however, was less affected than the larger. Elsewhere in the fields, we found them working on the leaves of Panic grass (*Panicum crusgalli*) in exactly the same manner.

THE GREASY CUT-WORM.

(*Agrotis ypsilon*.)

This was several times observed attacking corn in Louisiana; in one instance a stalk fully 10 inches high had been eaten into near the surface of the ground and destroyed.

Planters living in the low districts say that this or a similar species is very much more destructive just after an inundation.

ANTS.

(*Prenolepis nitens*.)

Various species of ants may be observed during autumn about the ears of unripe corn, especially if the kernels near the tip of the ears have been partly eaten by other insects or by birds. At La Fayette, Ind., during September, 1886, we several

times observed this species infesting the ears of corn, under circumstances which left no doubt as to their vegetal habits. The silk of the ears of corn where they were busily engaged was undisturbed, but down among its meshes were numbers of freshly-eaten kernels, and nothing but these ants in or about the ear, while the ants were very abundant.

Another species, *Formica schaufussii*, has been observed by us to eat kernels of seed wheat which had not been sufficiently covered after being sown in the field.

DRASTERIUS DORSALIS (?).

Larvæ which are supposed to be those of this species, as it is the only one of the genus common in Indiana and Illinois, have twice been surprised by me about La Fayette, under circumstances which lead to the suspicion that they attack corn. Although, as stated in report of last year, we have observed them in the vicinity of La Fayette attacking other larvæ, and other members of the genus are known to be carnivorous in the larval stage,* yet we have found them with their heads inserted in the stems of young corn, with no object about which could have induced them to do so if in search of animal food. These larvæ were very abundant in Mr. Lutz's field, previously mentioned as attacked by *Sphenophorus*.

CHINCH BUGS.

(*Blissus leucopterus.*)

These were observed in considerable numbers during March, 1887, in Tensas Parish, La., about young corn, pairing and ovipositing as in more northern localities later in spring. We are informed that considerable damage was sometimes done by the young bugs to the young plants. This rather contradicts the theory often expressed by northern farmers, viz, that certain crops, including Spring Wheat, are the cause of their abundance. In the locality where we observed them the only small grain sown is an occasional patch of Fall Oats, grown for fodder, and an occasional but equally small field of Millet.

CORTICARIA PUMILA.

Found in abundance on the tips of ears of young corn, feeding upon the kernels during August and September, in the vicinity of La Fayette, Ind.

CALATHUS GREGARIUS (SAY)† VERSUS THE COLORADO POTATO-BEETLE.

On June 7 of present year Mr. Charles E. Lutz, of Wea, Tippecanoe County, Ind., sent us examples of the adult *Calathus*, asking what they were, and stating that they were engaged in the destruction of the eggs of *Doryphora 10-lineata*. In proof of this he had placed quite a number of these eggs in the box with his specimens. On opening the box, however, a few hours later we were unable to find a single egg, although there was ample proof that there had been many on the leaves inclosed. Mr. Lutz further stated that where these *Calathus* were abundant there were no larvæ of the *Doryphora*, while where there was a lack of the former the eggs and larvæ of the latter were very abundant. He had placed eggs where the *Calathus* could find them, and observed them devour these and also attack the young larvæ.

June 13, I visited the location and found exactly the same state of affairs as above indicated. In a small field, near the barn and out-buildings where the domestic fowls had had full range, the *Doryphora* was very abundant in all stages. There were here but few *Calathus*, they doubtless having been destroyed by the fowls. But a mile away, in a field of 4 acres, the case was entirely different. Here there were no eggs or larvæ to be found, although the adult *Doryphora* was common enough. In fact, far more damage had been done by the adult *Systena blanda*, Melsh., and to a less degree by *S. frontalis*, Fab. Great numbers of the *Calathus* were hiding in the vicinity under clods about the plants, and I was informed that they were observed roving about over these plants during the cool of the day. There was hardly a trace of the destructive propensities of the arch enemy of the potato throughout the whole field, although it had not been treated with any insecticide for several weeks.

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*Am. Ent., vol. 3, 1880, p. 247.

† A short notice of this insect and its habits was published in the Indiana Farmer of July 30, 1887.—F. M. W.

Under date of August 12, Mr. Lutz again wrote me as follows:

"In regard to the *Calathus gregarius* my observations have shown me that he is a great lover of the eggs of the Colorado Beetle.

"I noticed that when one was seen wandering around over the potato plants, if a bunch of eggs were to be placed in his way he would stop and devour them, and was not easily driven away.

"Again, I selected an equal number of hills, one-half of which had no beetles under them, while the other half had. I placed eggs on the hills, and in the morning the eggs were all eaten where there were beetles, while the others were undisturbed. The next evening I placed beetles under the other hills, and in the morning the eggs were gone.

"I had no slugs on my potatoes until the last week in June, when the *Calathus* began to disappear. In a few days after they disappeared the slugs came so fast that it became necessary to apply Paris green."

This species of *Calathus* we have found very common in Illinois and Indiana, and less common in Mississippi, Arkansas, and Louisiana. Dr. Le Conte (Proc. Ac. Phila., 1854, p. 36) gives its habitat as "N. Y. to Fla., Texas."

A NEW ENEMY TO THE BEAN AND COW-PEA.

While in Louisiana, in April of the present year, I observed adult beetles of the species *Cerotoma caminea*, Fab., infesting bean-plants in gardens, where they destroyed the plants by first eating holes in the leaves and later eating out the whole leaf between the larger veins. They were also observed to attack the Cow-pea in great numbers, in the fields, after the same manner.

On June 22, while visiting Hon. Samuel Hargrove, at Princeton, Gibson County, Ind., we again caught the same species in the act of destroying beans in the same manner as I had observed them earlier in the season in the South.

The species is common but not abundant in the West, from Minnesota southward; being more abundant in Louisiana than in Indiana or Illinois. Some specimens from Minnesota and New York are almost wholly of a clay-yellow color. To the Cow-pea this may prove a formidable enemy, especially in the South, and the beetles may easily be confounded with *Diabrotica 12-punctata* by the unobserving.

THE STRAWBERRY SAW-FLY.

(*Emphytus maculatus*, Nort.)

Dr. Riley has elsewhere stated* that this insect was double-brooded, the adults from the first brood of larvæ appearing in late June and early July. These adults at once ovipositing, give origin to a second brood of larvæ, which enter the ground in August and remain in their cocoons until the following April, when they pupate, and from these the progenitors of the first brood of larvæ emerge.

From the fact that the first brood of larvæ mature simultaneously with the ripening of the fruit, thereby precluding the possibility of destroying them by arsenical solutions, much interest has been centered in this second brood of larvæ, which, appearing after the fruit was gathered, would give the fruit-grower an opportunity of adopting those measures of destroying them which were previously inapplicable.

During the twenty years which have elapsed since the life history of the species was first made known no one has noticed a second brood, although some careful observers have attempted to do so.

Prof. William Saunders states that on July 8, 1873, larvæ, some of them half-grown and others full-grown, were brought to him from a garden near London, Ontario. A number of these larvæ were placed in flower-pots containing earth and leaves, such as were full-grown disappearing in the earth at once. On July 23 an examination showed these larvæ in their cocoons unchanged, except by being contracted in length.†

Later Prof. S. A. Forbes states that larvæ fully matured were placed in a breeding cage at Normal, Ill., on June 21, 1884, and soon entered the earth therein. On July 19 these larvæ were contracted in length, but had not pupated. On September 1, and again on November 24, they were examined and found practically unchanged, and the adults finally emerged May 14, 1885.‡ These last studies seemed to settle the matter of broods, so far as it was possible to do so with artificial environments.

On October 5, 1887, in the fields of Mr. J. C. Stevens, near Richmond, Wayne County, Ind., we were not a little surprised to find larvæ of this species, varying

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*Prairie Farmer, May 25, 1867; Ninth Report Ins. Mo., p. 27, 1877.

† Fourth Report Ent. Soc. Ontario, 1873, p. 18.

‡ Fourth Report State Ent. Ill., 1884, p. 77.

from two-thirds grown to nearly full-grown, feeding upon strawberry plants, not single, but by hundreds. So abundant were they, in fact, that by remaining stationary we could count them by dozens on the leaves about us, and we advised Mr. Stevens to sprinkle the infested fields with Paris green and water as a protection against them next year.

The question as to what brood these larvæ belonged is a perplexing one. Assuredly they were not of the first, and the main point to decide is, were they the delayed second brood or were they a third brood. We confess being unable to decide the matter.

Below is given a tabular statement of the conditions most likely to influence the species during the time intervening between February 28 and September 30, although it seems hardly probable that meteorological influences could have caused any material change in the time of appearance of the first brood of larvæ:

Mean monthly temperature, variation of the same, and monthly rain-fall at Richmond, Ind. Lat. 39.51 *N.; elevation,* 969 *feet above the sea.*

1887.

	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
Mean temperature.....degrees..	37.3	50.2	68.5	72.7	83.3	71.1	64.7
Variation.....do..	67 15.52	84 25.59	84 52.32	94 58.36	101 66.35	96 50.46	92 30.62
Rain-fall.....inches..	2.48	4.16	3.76	2.32	2.18	3.45	0.84

THE WHEAT WIRE-WORM.

(*Agriotes mancus*, Say.)

It quite frequently occurs that fields of Fall Wheat suffer severely in Indiana by reason of the attack of Wire-worms, and, so far as specimens have been referred to us, the species has been determined as the one under consideration. The general verdict of farmers is, that these ravages are in fields which have the preceding year been broken up from the sward, and therefore it is the second crop which is injured.

The present season appears to have favored the development of these worms, and serious injury to young wheat by larvæ unquestionably belonging to this species has been reported from several parts of this State. A study of the fields infested reveals some interesting features, especially when considered in connection with remedial or preventive measures.

On the 17th of October of the present year opportunity was offered us to examine an infested field in the southwest part of La Grange County. The field consisted of 20 acres, and had been cleared of timber, excepting the larger stumps, and broken up several years previous, so that the present was the fifth or sixth successive crop. The present season no crop was raised, and in June the greater portion of the stumps were blown out with dynamite and the débris piled about the remainder and burned. The now entirely cleared field was plowed in June and harrowed twice before harvest (the latter part of June or first of July). After this it was cultivated once and harrowed once. Then, about the 15th of September, it was harrowed twice and sown to wheat. The preceding crops had consisted of both corn and wheat, and the only vegetation growing on the ground this season was a species of Amaranth, the turf about the stumps being nearly all destroyed in June. The present crop was, at the date of examination, damaged fully 35 per cent.

Mr. J. N. Latta, a very careful observer, residing in the vicinity of the field just mentioned, writes us, under date of November 17, that there are two other fields in the same neighborhood which are still more seriously injuredby Wire-worms. One of these fields was broken in the fall of 1886, and a crop of wheat sown thereon, the present being the second crop, both of wheat. The other field was one-half in clover and the other half in timothy. The first crop was of corn, the second of wheat like the present. The destruction in the latter field is greatest on ground formerly devoted to clover and least on that portion which was set with timothy.

Under date of October 23 Mr. F. P. Applegate, of Greensburgh, Decatur County, complained of serious damage to one of his fields of wheat by this pest, the injury being greatest on clay lands. Writing again under date of November 7, Mr. Applegate states that his field, injured by Wire-worms, was broken last March, and later planted with corn, having then been devoted to clover but one year. The pres-

ent crop of wheat was sown between the 15th and 20th of September. By October 23 fully one-fourth of the growing plants had been destroyed by the wire-worms, and a great deal of damage had been done by the pest elsewhere in his locality.

Mr. G. A. Applegate, of Mount Carmel, Ind., in a recent communication gives a rather abnormal instance, from which he states that the worst infested field in his vicinity was in Hungarian grass this year, the stubble turned over and the wheat sowed. This land was in corn two years, rye sowed among the corn the second year, and this followed by Hungarian grass, as stated.

Personally, we have had no favorable opportunity to study the habits of the species in any of its stages further than to remark its abundance in the adult stage during May about low grounds on the prairies, particularly those of Illinois. There we have swept the beetles in great numbers at night from low, dwarfed examples of the two species of willow, *Salix discolor*, Mahl., and *S. petiolaris*, Sm., and have also found them in great abundance under the débris deposited by suddenly swollen streams which ran through low prairie land.

It will be observed that the three preventive measures, spring plowing, summer fallow, and fall plowing, all figure in the notes here given, showing that whatever virtue these measures may possess lies in their being applied at some particular time and in a particularly thorough manner.

REPORT UPON THE INSECTS OF THE SEASON IN IOWA.

By PROF. HERBERT OSBORN, *Special Agent.*

AMES, IOWA, *November* 30, 1887.

SIR: I herewith transmit to you my report of observations for the summer of 1887. I desire to express my thanks to you and your assistants for the determination of doubtful specimens, and for the many other favors which you have been so ready to grant.

Respectfully,

HERBERT OSBORN.

Prof. C. V. RILEY,
U. S. Entomologist.

THE TURF WEB-WORM OR SOD-WORM.

(*Crambus exsiccatus*, Zeller, var.)

My attention was first called to this insect, which has proven a most serious pest the present season, by a note from Mr. Henry Barnes, who owns a farm near Gilbert, Story County. Under date of May 24 he writes:

DEAR SIR: Inclosed I send you bottle, in which are some specimens of a worm that is making sad havoc with our sod-corn. They eat the stalk off beneath the surface and many of the leaves are punctured full of holes. In some parts of the field nearly every hill is infested with the "varmints." Can you tell us how long they are likely to continue their depredations, so we can tell whether it will pay us to replant? The land from which the specimens were taken was seeded down some eight years since, and was mainly blue grass and white clover. Has been used for a sheep pasture about six years. Was underdrained and broken up last fall and this spring, and planted to corn with the above result. Will be greatly obliged for any information you can give us on the subject, and should be pleased to hear from you as soon as you can make it convenient, so that in case you can suggest anything likely to relieve us of the pest or enable us to escape his work we may have time to avail ourselves of the knowledge.

Yours, respectfully,

HENRY BARNES.

In reply I recommended replanting and stated briefly the probable history of the insect. This reply was published in the State Register, and shortly after the following letter was received:

OSSIAN, IOWA, *June* 9, 1887.

SIR: I have seen your answer to Mr. Barnes in the State Register of June 3. Now, my corn has been destroyed in precisely the same way. It was planted on the 8th

of May, and came up immediately and looked very nice, but it was taken in about two days, so that the field looked perfectly bare. We replanted on May 21. The corn came up very nice again; we have harrowed it and plowed once, but there will not be a hill in the field to-morrow night that will not be partially or wholly destroyed. This certainly can not be the same worm that is troubling Mr. Barnes, as they have been in my corn for three weeks, and I can not see any change in their appearance. As it is now too late to try corn again would it be safe to sow corn for fodder? The hay crop in this (Winneshiek) county is a failure, and this piece of ground has got to produce something. It was seeded to timothy and clover three years ago and has been used for hog pasture since that time. Inclosed find bottle containing specimens. Will be short of feed next winter and any advice or suggestion will be thankfully received.

Respectfully,

A. W. OXLEY.

To this I replied advising to put in corn, and stating my belief that the adults were already issuing from the chrysalis state.*

Early in June I had noticed the striped ground-squirrels on the college lawn digging into the turf and eating something which they withdrew. Examining the places thus dug up I always found the peculiar cocoon of a Crambus, and the place would also show the deserted web and burrow of the larva. These squirrels' burrows were very numerous in some parts of the lawn, and in one place I counted twenty-five in the space of a square yard, indicating that the ground-squirrel has disposed of that many larvæ or pupæ of Crambus within the given area. At another time I counted fifty to a square yard. Evidently when sod-worms are plenty the ground-squirrel is not an unmixed evil.

I did not at first connect these worms with the ones referred to by Mr. Barnes, but comparisons of specimens of larvæ found in sod here with the imperfect specimens sent by Mr. Barnes, and later with those from Mr. Oxley, satisfied me that they were very probably identical. Subsequent observations made this almost a certainty. I have therefore dealt with them as belonging to the same species.

Evidently we must consider it under the double rôle of a grass pest and a corn pest, and while it certainly causes in the aggregate vastly more damage to grass than to corn its work is more noticeable on the latter crop, since it so completely destroys fields planted upon sod infested by the young worms.

Since this insect has assumed so great an importance to two staple crops, and as its life history and habits have been but partially recorded, I have devoted as much time as possible to a study of it the present season and will give the result of my studies in detail.

Its distribution and injury so far as the corn crop is concerned may be gleaned in part from the Iowa crop report, which has kindly been placed at my disposal by the secretary of the State Agricultural Society, Hon. J. R. Shaffer. Aside from the localities given in the following list there was considerable damage in this (Story) county, and, as stated by Mr. Oxley, in Winneshiek County.

Extracts from crop report.

BREMER COUNTY.—Corn on old ground injured by a small green worm.

CLINTON COUNTY.—Cut-worms injured corn on timothy sod and old pastures.

DAVIS COUNTY.—Corn on sod and fallow ground has been destroyed by Web-worms.

FAYETTE COUNTY.—Corn looking well, notwithstanding the severe drought; some planted on timothy sod injured by Cut-worms, but general stand good.

HENRY COUNTY.—Meadow-worms working at the roots of grass.

VAN BUREN COUNTY.—A worm resembling the Cut-worm has done serious damage to corn; it built a web in the hill and would eat whole fields planted on new ground.

JOHNSON COUNTY.—Cut-worms destroyed 25 per cent. of the corn planted on sod.

JONES COUNTY.—Corn two weeks ahead of last year. That replanted on account of Cut-worms is gaining on the other.

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*In answer to further inquiries as to results in these fields Mr. Barnes informs me that the replanted corn was not materially injured by the worms, and that taking drought and Chinch Bugs into account produced a very fair crop. He further says that the portion of his field most damaged was the part plowed in spring. Mr. Oxley states that the worms took three plantings for him, but that he then planted to fodder-corn and raised a most excellent crop; he says worms worked in this a little at first, he thinks as late as June 27, but did no serious damage.

POWESHIEK COUNTY.—Cut-worms are doing some damage to corn.

WARREN COUNTY.—Corn somewhat injured by grub and Cut-worms, but as a whole prospects were never better for a good crop.

APPANOOSE COUNTY.—Some sod worms; no material damage from them as yet.

CEDAR COUNTY.—Corn injured by Cut-worms, on sod ground much had to be replanted.

CLARK COUNTY.—Corn damaged by Cut-worms.

DAVIS COUNTY.—Corn on sod taken by Cut-worms; many replanting the third time.

DELAWARE COUNTY.—Some timothy fields entirely destroyed by Cut-worms; many being plowed up and planted to corn.

JEFFERSON COUNTY.—Corn on old ground good, but is being destroyed by Cut-worms on timothy sod; much has been replanted.

JOHNSON COUNTY.—Corn a good stand, except that on timothy sod has been cut off by worms.

KEOKUK COUNTY.—Corn planted on sod injured by Cut-worms and much had to be replanted.

LEE COUNTY.—Corn generally good and forward for the season. New Web Wire-worm cut off most of the corn planted on sod plowed this spring.

POTTAWATTAMIE COUNTY.—Cut-worms and ground moles doing some damage to corn, but generally it is a good stand and color.

VAN BUREN COUNTY.—Corn planted on timothy sod being replanted the third time, Cut-worms taking all corn planted on sod ground.

WAPELLO COUNTY.—Corn on sod ground had to be replanted.*

The extent of its ravages in meadows in other parts of the State I am unable to give with any precision. On the college farm, both on the campus and in the pastures and meadows, it has been very abundant and the grass has suffered seriously. In patches the damage was such that it has not recovered; while over large areas the grass being cut off above the crown has grown up rapidly since the fall rains. During the severe drought, which extended till the 1st of September, the damaged portions did not show plainly, as the whole surface was dried up, but after the rains such areas were much slower in becoming green. But that the damage was not due to dryness was evidenced by the greatest damage occurring in depressions or in places where there was the most moisture, instead of on the tops of the knolls or in specially dry places. On the line of the Northwestern Road from Ames to Clinton I saw in the latter part of August many meadows and pastures presenting the whitened patches indicative of the presence of this pest. Outside the State, in Illinois and Wisconsin, I found evidence of it wherever I went.

The insect is distributed widely over the country, and I doubt not has been destructive in all the Upper Mississippi Valley, though probably a large portion of the damage done by it has been ascribed to the drought or other causes.

The injury to corn results only from planting upon sod. As it is very desirable to make this transfer when the meadows have been severely injured it becomes of the utmost importance to the corn crop to avoid the damage done, which necessitates replanting and causes vexatious delay. The measures necessary to avoid this damage I believe to be simple and practicable, and they will be fully stated under the head of remedial measures.

Habits and life history.—Owing to the abundance of this species upon the college lawn I have had opportunity to observe it during the entire season in all stages, and though some points of interest remain to be studied, I am able to state the principal facts in regard to its life history. Enough I am confident has been determined to form a solid basis for recommendation of remedial measures.

During the last of May and fore part of June larvæ and pupæ were abundant, and were observed as late as June 10. On June 7 the moths were plenty, and June 9 they were flying to lights in the houses by thousands. They came to my study in swarms, and I was afterwards told by students that they gathered to the electric lights in the college building in such numbers as to seriously interfere with their work. On the morning of the 10th, having closed the windows of my study the night before to prevent the moths from escaping, I counted over one hundred moths at one window, and the window-sill, the sash, and the floor in front of the window were thickly strewed with their eggs. On slightly pressing the abdomen of a female with thumb and finger she extruded, one by one, thirty-five eggs, after which none were extruded by pressure, but upon dissection of the moth I found ninety well-formed ova and a large but uncertain number of formative stage in tubes of the ovary. As this was a captured female and she had had time during

*I have included in the above extracts those given as Cut-worms, etc., though some of these very likely may refer to other species than *C. exsiccatus*.

the night to dispose of eggs which I did not count, I could not determine the full number possible from a single individual, but from those counted and those partially formed in the ovary it seems perfectly safe to say that each female can deposit at least two hundred eggs. The eggs are yellowish-white, oval in shape, with usually fifteen longitudinal ridges. In a few instances I noticed more. When extruded they are held momentarily at the tip of the abdomen, giving them time to dry, so they do not adhere to any object upon which they drop, but before the extrusion of another egg are snapped sharply away by a contraction of the lips of the vulva, which appears to be armed with a row of minute bristles. Eggs in this way were thrown quite a distance, and when being deposited in grass would be sent well down among the dead leaves at the surface of the sod. In a few cases I noticed one egg remain till the next was extruded, and the two would adhere slightly, but doubtless the natural extrusion is not so rapid as that induced by pressure.

On June 11 the moths still shut up in my room had deposited eggs in greater numbers than the night before, and some of them confined in a glass jar had also deposited many.

The eggs collected on June 10 hatched on June 18, and I infer that fertilization of the females had taken place previous to their flying to light. A point which I did not carefully determine is the proportion of males to females in those gathering to lights, but my impression is that the females were largely in excess.

Some of these newly-hatched larvæ were placed in a jar with earth and fresh grass, others in a jar without earth, while still others were scattered over a small area of grass out of doors in a place convenient for observation. These last could not afterward be found at all and the grass showed no signs of their presence. Being in a very dry location and the grass becoming badly dried up I suspect they did not obtain sufficient moist food to enable them to start their growth. The young larvæ when supplied with fresh grass collected at the broken ends and fed with avidity. Their bodies, at first pale, became after feeding yellowish-green, the head and upper part of the first segment being black. On the 20th I noticed that one of the larvæ had formed a tube by drawing together the edges of a blade of grass, while still others had gone under the earth at bottom of jar. Unfortunately, duties that could not be postponed prevented attention to these larvæ and a few days later they were all dead. One, however, had formed a basket-work attached to blades of grass. This had probably been formed as early as June 25. By the middle of July the larvæ were becoming conspicuous by their ravages in corn, and subsequent observations were made either directly in the field or upon larvæ collected and confined. Notes for July 13 and 16 record larvæ numerous in part of one field of sod-corn confined to a portion of the field last plowed. As the time of plowing appeared to be an important item I obtained, through the kindness of Mr. F. S. Schoenleber, the exact dates of plowing of the fields planted to sod-corn. One field plowed 9th to 11th of May contained no turf web-worms and no signs of their work. Another field had been plowed in part May 12, 13, 15, and 18. The remaining central portion was plowed on the 7th and 8th of June. The portion first plowed was entirely free from injury by worms, while the part last plowed was badly infested. The line of separation between that first plowed and that last plowed was in some places distinctly indicated by the missing hills or damaged stalks, indicating the presence of worms. It seems reasonably certain, therefore, that Crambus eggs were deposited on the central part in the grass before the sod was turned June 7 and 8, and the larvæ hatching by the 15th to 18th of the month had no other resource than to attack the corn which came on shortly after. As already stated, Crambus adults were abundant June 7, and had doubtless been present in fewer numbers for several days, so there was opportunity for the eggs to be deposited on the grass land prior to the plowing June 7 and 8; while from the absence of worms in the other sod-corn it was evident that no eggs were laid on the ground plowed previous to the first of June. None have, with possibly one or two reported exceptions, ever been found in corn-fields except when planted on sod. The exceptions, if referring to this species, may probably be accounted for in other ways than by assuming eggs to be laid on plowed land.

In corn the young worms construct a web from half an inch to an inch below the surface of the ground, usually winding it irregularly among the roots and stalks of corn. Frequently a number of these worms occur in a single hill, but as a general rule only one or two are found well developed. Hills infested by these worms have the stalks when small cut partially or entirely off, sometimes, I judge, the upper portion being entirely devoured. Larger stalks have cavities gouged out of the sides at the surface of the ground and a little above. The leaves also are eaten at base and numerous holes scattered over the blade. Sometimes these holes are arranged with a peculiar regularity, occurring in transverse rows three to five holes in each row, and the rows about the length of the worm apart. The stalks at

the surface of the ground are sometimes blackened and decayed, and in some instances I thought I detected their work on the roots. Naturally they do not find food in such abundance as in grass and may be expected to take whatever they can most readily attack.

On July 20 larvæ were found in corn apparently full grown and ready to pupate. Specimens confined in a glass jar with a little earth matured, two adults issuing and first noticed August 3, both fresh and apparently but recently expanded. Larvæ were found in corn as late as August 9, and from these I had one adult issuing during my absence and first seen by Professor Hitchcock August 25.

In grass land the larvæ form a web-lined burrow about half an inch beneath the surface of the sod, extending as the larva grows to a distance of 4 or 5 inches, nearly straight, and opening at the surface of the sod. The grass above and surrounding these burrows is cut off just at the surface of the ground; and where the worms are plenty the grass cut off forms a complete mat, which can be drawn aside, exposing the burrows of the larvæ. By pushing up the sod along the burrow the web and worm are brought to view. The roots and usually the crown of the plants, except directly above the burrow, are unaffected, though from the failure of some patches to revive even six weeks after rains have entirely restored other parts of the lawn it would seem that in some spots the worms were so hard pressed for food as to eat down into the crown. August 4, and for a number of days thereafter, full-grown worms forming cocoons could be found in abundance, and gradually adults became more numerous, till in the middle part of August and until the fore part of September they were again abundant. They were swarming to lights August 11. From this on the adult decreased in number, and the last record I have of seeing them is October 3.

This is as far as I have made positive observations on the species, but it is probably safe to infer that the eggs laid in the fall hatch and the young larvæ establish themselves in burrows where they pass the winter and awake to resume feeding in the spring. By the latter part of May the bulk of this brood is full grown, and, as we have seen, the moths issue in swarms between the 7th and 20th of June.

The insect is double-brooded, though scattering moths may be seen as late as last of June for the spring brood and as early as first of August and late as fore part of October for the fall brood.

The life history, as I have observed it and supplying by inference the winter condition of one brood, may be summarized as follows:

Moths of the spring brood appear in June; early stragglers by the 1st, the bulk of the brood from the 7th to the 15th, and late stragglers till the 1st of July. These deposit eggs which hatch in eight days from time of deposition. The larvæ require from five to seven weeks to become full-grown, forming in the meantime a web-lined burrow in the sod, within a portion of which or in sod close by they form a cocoon and change to the pupa stage. The pupa stage is passed in from twelve to fifteen days, the fall brood of moths appearing in August, early stragglers the 1st of the month, the bulk of the brood during the middle of the month and till the 1st of September, and late stragglers are seen till fore part of October. Moths of this brood deposit eggs for the fall and winter brood of larvæ, which larvæ mature by the latter part of May, pupating during last of May and fore part of June. These produce the spring brood of moths which appears in early June and the cycle is complete.

Description of different stages.—Reference has already been made to the appearance of different stages, and technical descriptions of some of the stages in other publications makes it unnecessary to go into detail here. I may state in brief, however, the most striking characters, in order that the insect may be recognized by those interested. It may be said, however, that it so closely resembles other species of the same genus that except to the professional entomologist a separation is next to impossible. Differences in habit, however, will assist in distinguishing them.

The egg is .55^{mm} long and .30^{mm} in diameter. It is fluted or ribbed longitudinally, the ribs numbering usually 15, rarely 16 or more. They are yellowish white, becoming darker as they reach the time for hatching.

The larva when newly hatched is .70^{mm} to .75^{mm} in length. The body is pale, almost white, while the head and upper part of the first segment is dark brown or blackish. The body is provided with scattering fine hairs. When full-grown it is nine-tenths of an inch long when extended, of a light brownish color, the head and upper part of first segment darker, and the head blotched with blackish. The segments following the first have glassy, slightly elevated, darker spots, from which arise fine hairs.

The pupa is bright reddish brown, half an inch in length, the terminal part obtuse and blackish. It is inclosed in an elongate oval cocoon made of a thin web and covered with green frass, which looks much like bits of grass cut fine, and indeed they seem to be but partially digested. A cocoon formed in a glass jar from corn

leaves seemed to be cut and used entirely undigested, and I surmise the material is cut especially for this purpose and passes directly through the body, to be used on the cocoon.

The moth is of a light ashy color, and fresh specimens show two obscure oblique dark stripes passing from the hind border toward the apex on the front wings. The wings are folded closely around the body when at rest. The length of the body is about one-half inch, and the wings expand an inch and one-eighth to an inch and one-fourth.

Remedies.—Under this head we must treat separately the measures to be adopted for corn and meadows or pastures.

As corn is attacked only when planted on sod, the damage being done by larvæ hatching from eggs deposited in grass or by larvæ that have partly obtained their growth in grass, all methods of prevention should recognize the time at which eggs are deposited and the larvæ mature.

When the worms are already at work in the corn the cheapest and best method is probably to replant, for the larvæ must all or nearly all mature by the middle of June at latest, and then no further damage need be feared. Reports show that this practice was successful, though in many cases fields were planted the third time. It would be well in planting on sod plowed late in the fall before to delay planting as long as practicable, thus starving out the majority, at any rate, of the worms, and then, if necessary, replanting as soon as possible when hills show presence of worms. If possible, however, the plowing should be done early in the fall, so as to prevent the eggs being deposited, or if deposited to starve out the larvæ before they have prepared for their winter fast. To be most effectual the plowing should be done before the 1st of September, and if the land be meadow land not used for fall pasture it will be safest to plow as soon as possible after the crop is off. When the sod is to be plowed up in spring it should be deferred if worms are present till they begin to change to pupæ, or for this latitude till the middle of May, and should be done before the moths make their appearance, or by the 1st of June. Our notes show that here sod plowed in May remained entirely free from worms, while that plowed the second week in June, just after appearance of moths, was badly infested. If noticed when they first begin their work on corn it is probable that the use of bisulphide of carbon would effectually destroy them, but it is doubtful whether it would be as satisfactory as replanting. The worms are easily detected, since they are to be found in their webs in the day-time, and they can be picked out by hand quite rapidly, as I know from experience. Possibly boys could be employed to collect them with good profit. These methods should be resorted to only in cases where preventive measures have not been employed. But in this case prevention is so easy that there seems little need of trouble from the pest when its habits are understood.

In meadows badly infested and thereby run out one method to be adopted, where circumstances will permit, is to plow up the sod and plant to another crop; but to avoid damage to the new crop, especially corn, the sod should be turned before the 1st of June, if in the spring, and if in fall before the 1st of September. If, however, the plowing is done prior to the egg-laying either of spring or fall the moths will fly to such pastures and meadows as are left and concentrate there, thus causing greater damage. On this account some plan should be adopted to prevent, if possible, that source of damage. If the land can lie after plowing to starve the worms it will be a good plan to defer plowing till eggs are laid and then turn them under to starve. In fact, knowing the cycle of life in the insect, and the time at which eggs are laid and the worms hatch and mature, each cultivator can adapt his measures to the special circumstances of his particular field.

A plan by which to greatly lessen the number of moths and the injury resulting from their presence in meadows and pastures may be based upon their habit of congregating in such immense numbers to light. I have shown that the moths thus attracted are in large part at least the females loaded with eggs, and it is probable that they have deposited few eggs if any previous to their flying to the light. Hence every female moth captured means the destruction of from one to two hundred eggs at the least. As the moths come to light by thousands, I think I may say even by millions, within a square mile, it can be seen how important is their destruction. Hundreds of them perish as a result of their own self-destructive habit, but by taking advantage of this habit and placing lanterns over tubs or pans of water in exposed places where they may be seen considerable distances, hosts of moths may be captured and destroyed. A little kerosene on the water will make their destruction certain, as then, even if they succeed in crawling out over those already submerged, or at the sides of the tub, they are quite sure to have received enough oiling to kill them in a short time. A little care in killing those accumulating in houses will also assist in lessening their number. Where electric lights

are in use they may be utilized to especial advantage in the capture of thousands of moths. I see no feasible plan of attacking the larvæ after they are established in the turf.

Natural enemies.—I have already mentioned the fact that the pupæ, possibly the full-grown larvæ, are extensively preyed upon by the striped squirrel (*Spermophilus 13-lineatus*). Unfortunately this sprightly little rodent has a taste for other food, which has gained for it a very unsavory reputation as a farm adjunct. Doubtless where corn is cultivated the injury to that crop will overbalance the good they may do in meadows; but I am inclined to think that for land kept constantly in grass their value is far greater than usually supposed. I know they feed upon the seed of grass and clover and doubtless also to some extent on the leaves and stems, but they also feed on noxious weeds and insects.

During several years' close observation of them on a lawn I have failed to find any indication of serious damage to the turf, and could they be kept in bounds I should feel like recommending that for permanent lawns they be allowed a home for the sake of the insects they devour. They seemed to select the cocoons of the turf-worms infallibly, pouncing upon a certain spot, digging for an instant, and then sitting upright to devour the dainty morsel.

Other mention of the species and related forms.—In his first annual report as State entomologist of New York, pp. 149, 150, Prof. J. A. Lintner gives the result of a breeding of one larva of *Crambus exsiccatus* in connection with a detailed account of the *Crambus vulgivagellus*, and there expresses the suspicion that the insect is double-brooded.

In the fourteenth annual report of the State entomologist of Illinois, pp. 12–17, Prof. S. A. Forbes describes under the name of *Crambus zeellus*, Fernald, an insect which in many respects resembles the species here discussed. In some respects, however, there is considerable difference, and I have not attempted to determine the relationship between them. This species described by Professor Forbes is mentioned and a letter relating thereto is published in Bulletin No. 12, p. 33, Division of Entomology, United States Department of Agriculture.

I can not overlook the possibility that there may be more than one species included in the records here presented, and indeed for the reports from over the State there is every probability that two or more forms are included under the general name of sod-worms, web-worms, etc.

The occurrence of *Crambus vulgivagellus*, for instance, in company with *exsiccatus* would account for several apparent discrepancies in reports concerning the time of pupation of the Web-worm. It has been my effort to record the facts as observed and reported, and the distinction of the different species, if such be included, must be worked out in the future. There can be no question, however, that the great body of the swarm appearing here the present season belongs to one species.

THE WHEAT-HEAD ARMY-WORM.

(*Leucania albilinea*, Guen.)

An insect which can without doubt be referred to this species caused very considerable damage in some of the southeastern counties of the State. Unfortunately I was not aware of the damage till too late to secure specimens for determination. Descriptions of the larva and its work, however, are so characteristic that I feel confident it was this species. I subjoin extracts from the Iowa crop report for July 10, 1887, which will show the distribution and damage so far as reported.

It will be noticed that the area included extends from the Mississippi River to a little west of the middle of the State and comprises only the two southern rows of counties, with the exception of Adair, which corners to the northwest upon the last infested county in the second row. Estimates given for two of the counties place the loss at 75,000 bushels (equal to about $150,000) in one (Jefferson) and at $30,000 in the other (Wayne). It is possible that these estimates are too high, but if we cut them down one-half and suppose the other eleven counties reported to have suffered in like ratio it would make a total loss of over half a million dollars for the thirteen counties. Doubtful counties out of this area may have suffered more or less, but not so conspicuously as to attract attention. The moths were noted at Ames during the summer, but not in unusual abundance.

Extracts from Iowa crop report.

ADAIR COUNTY.—There is some new insect eating off timothy heads.

APPANOOSE COUNTY.—Timothy heads eaten off by worms. There will not be any seed in Franklin Township. Within the last fifteen days a worm looking like an overgrown measuring worm made its appearance on timothy heads and com-

pletely stripped many pieces, damaging the crop very much; they have disappeared. Timothy light, a small green worm eating off the heads. Timothy heads destroyed by a small green worm.

CLARKE COUNTY.—A worm working on timothy heads.

DAVIS COUNTY.—Worms are eating off timothy heads. Timothy heads eaten off by a peculiar green worm, name unknown. Timothy heads destroyed by a small green worm.

DECATUR COUNTY.—Green worms working on timothy heads. Worms have destroyed timothy heads. Green worms playing havoc with timothy heads. A worm has almost destroyed timothy heads.

DES MOINES COUNTY.—Timothy heads eaten off by a small green worm.

HENRY COUNTY—A light-green worm 1 inch long has done great damage to timothy heads. A green worm did some damage to timothy heads, but has disappeared. Meadow worms working at the root (of timothy) and a green worm about 1½ inches long, name unknown, working on the head. Timothy heads destroyed by worms. Timothy badly damaged by a small green worm eating the head. Timothy being cut to save it from worms.

JEFFERSON COUNTY.—Some worm working on timothy heads, stripping off chaff and seed and leaving stems naked. Timothy seed, of which this county usually ships about 75,000 bushels, will not exceed the wants of home consumption.

LEE COUNTY.—Timothy injured by a small worm eating off heads. A small green worm has done great damage to timothy heads and is working on oats. Timothy heads destroyed by worms.

LUCAS COUNTY.—A green worm has appeared on timothy heads and will materially lessen the seed crop. Bountiful rains June 10 to 18 promoted growth of timothy 10 per cent.; a worm from half to two inches long appeared about the same time and has devoured whole fields. They do their work principally at night. Timothy seed has been completely destroyed by myriads of green worms. A worm doing damage to timothy heads. A small green worm doing great damage to timothy heads.

RINGGOLD COUNTY.—Timothy will be a short crop in many fields; heads of timothy entirely eaten off by a green measuring worm. Grasshoppers and worms heading timothy; small green worm eating off timothy heads.

VAN BUREN COUNTY.—Timothy heads eaten off by worms. "Army-worms" are destroying timothy meadows. Timothy damaged by drought and a small green worm working on heads.

WAYNE COUNTY.—A worm, name unknown, cutting off timothy heads. Sod (of timothy) injured by spring drought and latterly a worm eating off the heads. There is a small green worm doing much damage to timothy heads. A worm three-quarters inch long is eating the timothy; will not be more than 10 per cent. of a crop, a loss of $30,000 to this county. Timothy heads destroyed by worm; timothy heads eaten by worms. A worm resembling a Cabbage-worm is destroying timothy heads. A small green worm eating timothy heads.

BLISTER BEETLES.

(*Lytta cinerea* and *Epicauta vittata.*)

Two species of these common beetles were unusually abundant this season, doing considerable damage to various plants, and in a number of instances causing quite serious blistering upon the faces and hands of people. I noticed an item in the daily paper to the effect that in a certain town in Missouri they were so plenty, flying into houses by night and producing such severe blisters, that people were obliged to avoid lighting lamps in the evening. Several of the college students suffered from blistered faces after handling the *cinerea*, and I was myself adorned for several days with a swollen face, having, as often before, gathered a number in my hand and probably while perspiring brushed some part against my face.

Lytta cinerea was the species first noted as abundant. June 7 and 8 it was plenty and stripping leaves of Honey Locust. June 9 I observed some of the beetles feeding upon clover, and that evening noted it attracted to my light. Specimens were received from Hancock County, where it was reported destructive, and it was also reported destructive to potatoes in Cerro Gordo County.

The Striped Blister beetle (*Epicauta vittata*) damaged some of the potato patches in and about Ames, and July 20 I noticed them plenty on injured corn, but as grasshoppers were present they may not have caused the damage. The following items from the crop report apply, most of them certainly, to this species, while some may apply to either this or the preceding species:

ADAMS COUNTY.—A long striped bug is eating potato vines.

CLARKE COUNTY.—Potatoes damaged by a long striped bug.

CLINTON COUNTY.—Flying potato-bugs threaten late potatoes. The Spanish Fly is very destructive to the potato crop.

HENRY COUNTY.—Potatoes have been badly eaten by the long striped bug.

JACKSON COUNTY.—A new species of potato-bug has appeared, but as yet no damage done.

JOHNSON COUNTY.—We have Colorado and two kinds of long bug, the latter headed off by Paris green. Army bugs are very bad on potatoes and corn. Colorado beetles appeared in small numbers and needed no attention, but the flying variety are extremely numerous and doing great damage to potato crop.

MONTGOMERY COUNTY.—A new variety of potato-bugs has appeared, doing great damage. They made their appearance June 8, and are equally destructive as the Colorado and far more difficult to destroy.

Many complaints have come to me that these Blister Beetles can not be killed with Paris green or London purple. This, I think, must be due to the insects traveling about so much, and thus leaving places that have been poisoned for their benefit. If care is taken to spray the whole patch, and especially parts not invaded by the pest, the result would, I think, be much more satisfactory. It should be remembered, too, that especially with London purple effects are not to be noted for from twenty-four to forty-eight hours after application. It should of course be remembered that in the larval stage these insects are beneficial, so that where they become destructive to some valuable crop, should they be destroyed?

THE FALSE CHINCH-BUG.

(*Nysius angustatus*, Uhler.)

The life history of this species, so far as I can find and as I have been informed by Professor Riley, who desired especial observations on the unknown points, has never been fully stated in that no record of the eggs or their place of deposition has been published.

As the species has been quite abundant here I undertook to determine this point, and in July, when adults were plenty and copulating, I made careful search in the ground around roots and among the leaves and blossoms of the common trailing Amaranth (*Amarantus blitoides*) where the insects were most abundant. My search was rewarded July 19 by the finding among blossoms of an egg which seemed reasonably certain to be the one sought, and careful comparison with eggs dissected from gravid females proved them to be identical.

The egg is slender, cylindrical, yellow, irregularly wrinkled, and tapering slightly at both ends. The smaller end is orange red. Evidently this is the head end and the orange-red color due to the eyes in process of formation. In eggs from dissected females this color is more diffused and less conspicuous. While eggs may doubtless be deposited elsewhere than upon the Amaranth this may with certainty be stated as one of the places of deposition, and in this locality this weed appears to be the chief food plant of the species. The cases recorded by Professor Riley, however (Mo. Rept., V, pp. 111–113), show that it may at times prove a serious pest. Where their destruction is desired it is evident that collecting and destroying the Amaranth during and after the time of egg deposition would be a preventive measure easy to apply.

A few pupæ and numerous adults, some of them copulating, were observed November 15. Probably these adults winter over to deposit eggs in the spring. I have not, however, seen the adult in the early spring. As the spring brood does not mature till July, and as observations have failed to show any brood maturing between this and late in fall we may consider that for this locality only two broods are produced annually.

On July 14 (evening) I took a number of examples and noted many others that had flown to lights in my house, passing through the mosquito netting that covered the windows.

NOTES ON MISCELLANEOUS INSECTS.

Crepidodera helxines was quite abundant in May and caused considerable damage to the leaves of Poplar and Laurel-leaf Willow. *Disonycha abbreviata* was found upon seedling plants of *Eleagnus*, and I was informed that it was seen eating the leaves. The plants were considerably damaged and no other insect likely to do the damage was present. None were seen after May 20, and no further damage to the plants was observed. *Haltica chalybea* was observed here for the first time on grapes. Adults were seen May 18 and larvæ appeared in June, but no serious damage resulted here. Farther south in the State they caused serious injury.

Anomœa laticlavia was abundant and (June 9) observed stripping leaves of Honey Locust. It fed particularly upon the young leaves on sprouts. Many were noticed *in coitu*, the male with antennæ kept fully extended, and body of male nearly at right angles to that of female. No eggs were found, and none were deposited by beetles in confinement, but those dissected from female were .65 to .70^{mm} long, .40^{mm} wide, oval, some slightly reniform, yellow, and smooth. Twenty-two were taken from one female.

Phyllotreta vittata quite abundant and injurious to cabbages. They were observed (June 28) very plenty on leaves above and below, and one plant was badly injured by their attacks on the stem just above ground. They were also quite plenty on Horse-radish leaves.

Diachus auratus was found (June 29) eating the blossoms of Red Clover and depositing its eggs in the clover heads. The egg is oval, light brown, and covered with minute irregular projections and short, spiny protuberances. The egg before extrusion is smooth, but while passing out is coated with a glutinous substance which hardens and forms the spiny coat. This coat is started upon the end first extruded, and the egg, during extrusion, is gradually rotated by means of the hind legs. This, I take it, is to bring each part of the surface under the openings of the glands secreting the glutinous substance. Looked at from the direction of the insect's abdomen the rotation was in same direction as hands of a watch, for those I observed. Eggs kept in a glass tube (inclosed June 29) were found hatched the morning of July 13. Some of the larvæ had crawled from their egg cases; others were within, except head and legs, and drawing case about with them. Larvæ have the head reddish and the body and legs white. I attempted to feed these on fresh clover heads, but did not succeed.

Alydus eurinus has become quite abundant during past two or three years and occurs quite commonly upon Red Clover. July 21 I watched one closely for some time to see if it fed upon the clover, being careful not to disturb it, as they fly very quickly on approach of danger. It could be seen inserting its beak occasionally, then gradually withdrawing it, and to all appearance feeding. Examination of the clover head showed no insects, except a few larvæ of *Phœlothrips nigra* and one larva of *Anthocoris insidiosus*, none of which showed any signs of injury. The *Alydus* could not have been feeding upon them. The habits of allied species would favor the vegetable diet, and I believe it may be added to the long list of clover pests.

Anthocoris insidiosus, a well-known species, has heretofore been credited with preying upon certain noxious insects, and this summer, finding them plenty in clover-heads with *Phlœothrips nigra*, I tested its relation to this species by placing (June 29) one of the pupæ in a glass tube with a number of adults and larvæ of the latter species. In a very few minutes it had red larva impaled and quickly sucked out the liquid contents of its body, so that it was shrunken to simply a head, terminal segment, and legs. On June 30 I placed an adult *A. insidiosus* in tube with clover plant-lice of different sizes and with adult *Phlœothrips nigra*. It made no attack upon the other insects at the time, and on July 1 had not eaten any that I could determine. Some of the plant-lice had molted, and this I concluded would account for all shrunken skins present. On July 2 the plant-lice were all dead, only shrunken skins remaining, while the *Anthocoris* was still active. It seems probable that the plant-lice were eaten by the bug, since being supplied with fresh food they might be expected to survive more than forty-eight hours. I also saw the *Anthocoris* inserting beak into tissues of fresh clover blossom. It did not attack the adult thrips.

Piesma cinerea.—The Ash-grey Leaf-bug occurred the past summer in great numbers, but was not observed as abundant on any but noxious plants. A very few were noticed in spring on Grape but no damage to be seen. The same may be said of their occurrence on Plum. July 1 they were noticed in great numbers on *Amarantus retroflexus* (Pigweed or Amaranth), mostly paired, and on the under surface of leaves were numerous eggs, which I took to be of this species. This I proved by confining adults and securing eggs, and further by watching development of larvæ. A very few young larvæ were also noted at this time. The eggs are yellow, elongate, slightly bent, with about ten longitudinal ribs, the head end cut square off, and the red eyes showing plainly in eggs nearly ready to hatch. The larvæ when first hatched are two-thirds of a millimeter in length and a fourth of a millimeter in width, the antennæ four-jointed, the eyes red, and a red spot showing very plainly in the abdomen. By July 12 many larvæ on the plants observed were over half-grown, being at this time green in color. July 19 all stages were abundant, but many in pupa stage and many adults apparently fresh from the pupa stage with the wings delicate, almost white, and the body throughout green, except the red eyes. Two pairs apparently recently-issued adults were noticed *in coitu*. The green color is evidently retained for some time after reach-

ing the adult stage. This species was also observed, though less abundant on *Amarantus blitoides*.

Erythroneura vitis was abundant throughout the season, as also *Thrips tritici*, and *Phlœothrips nigra* was present in immense numbers in clover blossoms, both as larvæ and adults, and I think there can be no question but that they get their nourishment from the plant. There seems, however, to be no very decided injury as a result of their presence, though it is to be noted that many clover heads where they are present blacken early and do not set seed apparently as full as they should. I have seen adults of the latter species working their jaws rapidly on the tissues of clover blossoms, but could not discover any of the tissue bitten away.

Tetranychus telarius.—In addition to the usual plants infested by this mite I have observed it this season in egg, larval, and adult stages upon the leaves of clover, their presence being indicated by the usual yellowish or rusty blotches.

REPORT ON THE SEASON'S OBSERVATIONS IN NEBRASKA.

By LAWRENCE BRUNER, *Special Agent.*

WEST POINT, NEBR., *October* 24, 1887.

SIR: Herewith is submitted a report of my observations in the State of Nebraska and adjoining regions during the current year, being incidental to our conjoint work on the *Acrididæ*.

Very respectfully,

LAWRENCE BRUNER.

Prof. C. V. RILEY,
U. S. Entomologist.

INTRODUCTION.

The present has been an uncommonly favorable year for nearly every species of injurious insect that is thus far known to occur within the borders of Nebraska and adjoining States. A close, rather severe winter, followed by a moderately late spring without rains and changing to a hot, dry summer, has been the chief cause for this undue increase of noxious insects.

Among the insect depredators that have come to my immediate notice during the year the following are chief:

Chinch Bug, Codling Moth, Strawberry Crown-borer, Cottonwood Leaf Beetle, Colorado Potato Beetle, Cabbage Butterflies, Willow Sawfly, Ash Sawfly, Walnut Caterpillar, Corn Worms, Cut-worms, Larva of Swallow-tail Butterfly on Ash, Weevils in seeds of Ash, several species of locusts, native and migratory, and three or four species of beetles on the native willows.

COLORADO POTATO BEETLE.

(*Doryphora 10-lineata.*)

This beetle began operations rather later than usual, from which fact I had anticipated a year of comparative immunity from its ravages, which fact, I think, was mentioned in one of my letters to you at the time. During June, however, potato-fields began to suffer, and picking after picking of the mature insects appeared to make no impression on their steadily increasing numbers. Paris green and London purple alone saved such portion of the crop as was saved. Not until quite late in June and the early part of July did its natural enemies appear to be able to accomplish anything perceptible in the way of checking its rapid increase. This state of affairs was the general rule. In my garden, however, the crop was more favored, scarcely a beetle appearing until after the plants were all in blossom, and the first brood of the season made its appearance. From this time on they came in "swarms," and picking by hand availed but little. Soon the vines were covered and the leaves disappeared as if by magic. Now came the enemies, also quite numerous, various species of Lady-birds, Carabidæ, and two species of Hemiptera (*Arma spinosa*, Dallas, and *Perillus claudus*, Say), the latter not heretofore known by me to feed upon this insect. In fact I never saw it before that I remember of. When digging

potatoes about a month ago I saw at least fifty of them on a piece of ground about 20 by 40 feet in size, in different stages of growth, ranging in size from 2^{mm} in length up to the fully matured insects, which are from 8^{mm} to 9^{mm} in length. Since that time I have seen one or more daily creeping along the outside of the house or along the window and door screens. Only the mature insects were observed in the act of devouring the beetle larvæ.

This undue increase in the Colorado Potato Beetle is attributed to the long-continued and excessive drought with which this section had been visited. During the past three months we have had ample rains, and the result had been the almost immediate disappearance of the pest, which had just begun work on the tomato and various other solanaceous plants when the rains came.

CHINCH BUG.

(*Blissus leucopterus.*)

Great and wide-spread have been the depredations of this repulsive pest, which next to the Rocky Mountain Locust is our most injurious species of insect enemy. From its depredations alone throughout the drought-stricken region of the Mississippi and Missouri valleys, during the present season many millions of dollars' worth of grain have been destroyed, and in several localities actual privation is liable to follow.

The annexed crop reports, culled from various daily and weekly newspapers published throughout this region, will give a slight intimation as to the true state of the subject under consideration. Still, each region always draws its own afflictions as mildly as possible, while in speaking of those of a neighboring district they are liable to be somewhat overdrawn or exaggerated.

About the beginning of the second week in July rumors of Chinch-bug depredations at isolated localities throughout the drought-stricken area were first circulating through the press. A week later these rumors had become substantiated, and it was definitely known that their distribution and depredations were more wide-spread and general than was at first supposed; not only in this State, but also in Kansas, Missouri, Iowa, portions of Illinois, Minnesota, and southeastern Dakota. But not until harvest arrived was the full extent of their depredations known.

Causes of increase.—When the matter is carefully studied and the causes of the undue increase of this insect are taken into consideration the wonder is that the injury was not greater and more wide-spread than it actually has been. The long-continued drought of last year, with large areas of Chinch-bug depredations, followed by a generally close and rather severe winter, after which came a warm, dry spring and hot, scorching summer; all these favored in the greatest degree the most complete development of the bug in all its stages. But comparatively few of its natural enemies were present; and most of these, too, being species that prefer preying upon other insects to feeding on the unsavory rebel under consideration when they can be found. These predatory species had a plentiful host in the various species of Aphids, leaf beetles, and such like other depredators that were also present in great numbers.

One of the common and perhaps by far the chiefest of reasons for the large numbers of the pest that are always ready to take place whenever the advantage offers is the great carelessness of farmers in general to "clean up" during late fall and early spring. Especially is this true in portions of Nebraska, Iowa, and Kansas. The bugs winter among rubbish of all kinds, in meadows, along fences, in brush heaps, among fallen leaves, and among the débris collected by hedges, weed patches, and along the outskirts of groves among the underbrush. But there is no use of my going over these points that have been mentioned again and again by all writers upon the subject.

After the bugs have become a pest, the only effectual remedy is wet, cool weather. For some reason or other their constitution is not suited to a superfluity of moisture, nor can they adapt themselves to it. Humidity has the effect of bringing on disease and final dissolution with them, just as it does with various migratory locusts, the only difference being in favor of the locusts. A good, soaking rain, or at most two or three of such, following in the course of several days, generally ends effectually the most threatening Chinch-bug devastation, while on the other hand a year or even two of such weather are sometimes required to entirely obliterate a locust plague.

The question, then, naturally comes up, can this insect not be materially kept in check by some other and natural means? My answer to this question is, yes; to a certain degree, this is quite possible, and not nearly so difficult a task as one might suppose. A good cleaning up and burning of rubbish of all kinds in late fall, winter, or early spring, will answer the purpose, if the work be general, by reducing the number of hibernating insects. Osage orange and all other very brushy hedges are

the most attractive retreats, and at the same time most formidable retreats to master. For my part, I would be in favor of removing these and replacing them with some other kind not so difficult to keep free from the collecting débris carried by winds. Uncultivated prairie lands adjoining fields should also be burned early in spring. The breaking down and burning of corn-stalks in spring following a Chinch Bug year will also destroy myriads of the insects that have hibernated between the leaves and stalks. At other times, however, the stalks had better be utilized as manure by plowing under. If covered deeply, this will be a remedy fully as effectual as if burned. Protect the birds, and above all the quails, for they destroy countless numbers of hibernating insects of various kinds that are to be picked up about hedges and such like resorts frequented by these birds throughout the year. Although belonging to the granivorous birds, the quail is essentially insectivorous, except during inclement weather, when insects are not easily obtained. In my profession as taxidermist I have dissected many different species of birds, in the crops of which were contained injurious insects of various kinds, the Chinch Bug among the others. In no other instance do I remember of the presence of this insect in the crop of a bird in so great numbers as in that of the quail. As a rule, but few birds, mammals, reptiles, or rapacious insects seem to relish any of the odoriferous members of the order Hemiptera or true bugs. In winter, however, this repugnance is partially overcome, and now and then even a Chinch Bug seems a delicate morsel when "meat" is scarce.

Very few insects are known to prey upon the Chinch Bug; while I, myself, have never observed any of the species which have been credited with the good work—this attacking the enemy. True, I have frequently seen different species of Lady-bugs (*Coccinella*, *Hippodamia*, etc.), and the Lace-wing fly upon the same corn-stalk with the Chinch Bugs. Upon close observation it was also ascertained that the plant was more or less infested with some Aphid or plant-louse which had attracted these, their natural enemies, before the other bugs arrived. It must not be inferred from what I say here that I discredit the writings of such authorities as Thomas, LeBaron, and others. Such is far from my intention.

Various remedies, as plowing, rolling, ditching, fencing, and the use of insecticides have been suggested and used with more or less favorable results, both in this and other States; deep plowing immediately after harvest having succeeded in a few instances by covering the bugs so deeply that they could not creep out. Rolling at a like season has crushed large numbers, while ditching and fencing have succeeded in "bunching" them, and for a time checking their onward movement while migrating from small-grain fields to corn-fields. At such times the dragging forward and backward of a heavy weight of some sort has been the means of causing great slaughter among their continually increasing ranks. Ditches into which water could be turned have formed complete barriers to their creeping migrations, but not to the after movements of the winged insects as they were about to mate for the second brood.

This insect, like all other depredators, has its likes and dislikes, and chooses its food-plants with considerable daintiness of taste.

The small grains are the first on the list, after which follow some of the grasses and corn. Among the grasses Millet, Hungarian, and Fox-tail stand at the head, while a few others that usually grow as weeds follow closely. Wild Buckwheat is also quite a delicacy with them, and I have noticed several examples where weedy fields were less injured than clean ones, notwithstanding the fact that the one contained equally as many bugs as the other. Several farmers in this country have also mentioned the same fact to me. As a rule, grain in a grassy field has the disadvantage alongside of that growing in a clean one. During the past summer I saw several examples in which the scale was turned. One of these in particular attracted my attention at the time. The crop was corn, growing just across a road from a field of wheat which had been so badly damaged as to render its harvest useless. The ground was covered with wild Hungarian or Fox-tail grass which at the time, August 6, was dead and perfectly dry for a considerable distance in from the road. Upon examination it was found that our old acquaintance was at work here, attacking the Fox-tail in preference to the corn. Referring to my notes made on the ground, I find the following:

"The Chinch Bug is still present in considerable numbers in a few corn-fields, but absent from others where there are signs of its work. In these a large per cent. of the grass (Fox-tail) has been entirely killed before the corn was attacked. In no instance has the corn been greatly damaged, the only perceptible injury being in the drying up of a few of the lower leaves."

We had several heavy rains just prior to this, so the partial disappearance of the pest could very likely be attributed to that cause. Since that date but a few scattered specimens of the bugs have been noticed. Hence, I imagine our rains of August and September have been of great benefit in their diminution.

In conclusion, I would state that the only remedy that I know of is in clean farming—burning all rubbish in early spring that has not disappeared during fall and winter; also the protection of our winter birds.

In regions that depend entirely upon irrigation for moisture, or such that are easily flooded, there never need be any loss of crops from the depredations of this insect.

As to future possibilities of injury we can say nothing definite, as weather alone will decide the matter, a wet year preventing and a dry one favoring their increase in damaging numbers.

LOCUSTS (grasshoppers).

During the month of June reports of the ravages of our old enemy, the Rocky Mountain Locust (*Melanoplus spretus*, Thos.), in one or two localities in the Northwest were going the rounds of the press, especially Eastern papers. Just what these ravages amounted to I am unable to state, not having been upon the ground. Neither am I prepared to predict anything in reference to their numbers and probable whereabouts for the future. That this insect was on the increase two years ago, when I last visited the region in question, I am positive. From the occasional references to their appearance at widely-separated localities since, and the frequent scattering flights observed to pass over this locality, both during the summer and early fall of 1886 and the present season, I am pretty certain their numbers have not decreased.

The Ottertail County, Minn., visitation is evidently more familiar to you than to myself; therefore I merely add the newspaper clippings referring to it that have come to my notice.

A few *spretus* alighted here about the middle of June, which arrived from the south. Others appeared July 10 to 12 from the north, and still others were seen in the air during the latter part of July and up to the 20th of August, the latter also moving southward, either from north-northeast or northwest. At no time were these flights what would be called large; still, when taken together, the numbers that passed would have comprised quite an extensive swarm. The only ones that were observed to deposit eggs were those which came in July, just before the harvest had fairly begun. From these there will be no danger next year, as their numbers were too few.

On account of the severe drought during the last and the present year, the various species of native locusts have become exceedingly numerous in some localities, where they congregated from the surrounding prairies in such great numbers as to materially injure the outer edges of grain-fields, as well as to clean out many gardens. On the 12th of July, while out on the uplands, 3 to 4 miles east of town, I found these "natives" in large numbers in the ravines or low places where the grasses were still green, as well as along the edges of grain-fields. They had congregated from the adjoining higher grounds, upon which the grasses had dried up and withered.

Melanoplus angustipennis, Dodge, which only a few years ago was quite rare and confined to the lowlands along the Elkhorn, is now becoming quite numerous. If the species continues to increase as rapidly during the succeeding four or five years as it has during the past few, it will be equally as destructive as *femur-rubrum*, *devastator*, *atlanis*, and *differentialis*. When first described it seemed to be confined almost exclusively to *Artemesia ludoviciana* as a food-plant. Now it seems to take to almost any food-plant that presents itself. This Narrow-winged Locust is more nearly related to *M. devastator* than to any of our other especially injurious species. Should it really become a pest, as present indications would suggest, its "arboreal" habit of living to a very great extent above the surface of the ground upon the stems and leaves of plants renders it rather a difficult enemy with which to deal.

Stenobothrus æqualis, Scudd.—At about 4 o'clock p.m. July 18, while walking through an orchard, I noticed several small grasshoppers spring into the air and start off on a flight, seemingly unmolested or unconcerned as to time of re-alighting. These locusts were so much smaller than any of the species heretofore observed by me to act in this manner that I decided upon an investigation. I accordingly watched for others as they arose and sailed joyously aloft, when one chanced to drift within reach of my net and thus suddenly ended his anticipated spree. Imagine my astonishment when the capture was ascertained to be a specimen of our common *Stenobothrus æqualis*, of the form approaching *St. maculipennis*. Further inquiry confirmed the fact that the recent capture was really one of many of these locusts that had actually decided upon a journey, and were on a move southwestward. By the aid of a field-glass it was estimated that some of these small locusts actually attained an altitude of upwards of 400 feet above the surface, while still higher were to be seen the larger specimens of *M. spretus*, of which a few were passing in the same direction.

The *Stenobothri* can be distinguished in flight from the former by their much smaller size and more slender form and by their more rapid-moving wings. They also fly with their body more nearly horizontal than do the various species of *Melanoplus* and *Camnula pellucida*.

I do not suppose that the flights of this locust as observed to-day are so extended nor so frequent as they are with the species which have heretofore been observed to migrate. Nevertheless, that there was a true migration in this instance I do not doubt. It may be argued that their leaving the stubble-field (for such it was where this action was first observed) was a necessity, and could have been accomplished in no other way. Be that as it may, there were others in the air enough higher to have come from considerably beyond the confines of the small field in question. Besides, they were seen from other localities later in the afternoon. The wind at the time was gentle, possibly 6 to 8 miles an hour.

My impression is that many more of the Acrididæ, as well as other members of the order, are at times migratory. Besides these *Stenobothri*, I also observed during August and September a similar movement among the long-winged variety of *Nemobius bivittatus* and *Œcanthus nigricornis*. These latter were leaving a recently-mown meadow, upon which the grass was still green. They also rose to a height of several hundreds of feet, and drifted with the wind in a similar manner to that employed by the migratory locusts. Nor did they alight immediately after crossing the intervening meadow, but kept steadily onward as far as the eye could follow them. Of these crickets at least two dozen, divided about equally between the two species, were noticed on the move. I only remained in the meadow about one hour, during which time I was collecting.

CABBAGE INSECTS.

Both the Rape and Southern Cabbage butterflies were quite numerous during the summer, and their larvæ did considerable injury to cabbages throughout this portion of the State. When compared with last year, I think the southern species (*Pieris oleracea*) was present in larger numbers this, while the Rape Butterfly (*P. rapæ*) was fewer than then.

I observed *oleracea* to be more partial to the pepper grasses than to cabbages. It also deposited eggs upon various cruciferous plants growing both in the garden and about the house. The *rapæ*, on the other hand, stuck to the cabbages, kahl, and rape, the latter of which grows promiscuously over the fields as weeds throughout the country.

Besides the larvæ of these two butterflies I also observed the small larvæ of *Plutella cruciferarum* in considerable numbers during the earlier part of the season. During August and September but few of them were seen.

The cabbage-louse, generally called mildew, was also very numerous and caused some little damage in a few localities during August and the first week in September. The same insect also attacked two of my melon vines and a small patch of sweet corn, but were soon mastered by the lady-bugs, which flocked in by the hundreds.

THE CODLING MOTH.

(*Carpocapsa pomonella.*)

This insect is becoming so numerous and destructive that comparatively few apples escape without a worm or two. In several orchards that I have examined during the season the finding of a perfect apple was rather more of a "chore" than one would suppose might be the case in a new country where apples have been raised but three or four years, and that, too, in rather small quantities. Either the moths must migrate in large numbers, or else this insect also infests some native plant. I have often found similar larvæ in both rose-buds and the thorn apple. Whether these were those of *Carpocapsa* or belonged to some other genus I do not know, as I have never tried to breed them. I do not think the increase of our Apple moth has occurred entirely at home, for but few apples go to waste, even the "windfalls" being utilized in almost all cases.

FOREST-TREE INSECTS.

Among the insects that have been more or less injurious during the past summer the following species were most conspicuous:

Affecting the Ash, larva of *Papilio turnus*, *Monophadnus barda*, *Thysanocnemis helvolus*, and *T. fraxini*. The *Papilio* larvæ have been exceedingly numer-

ous and destructive in portions of Antelope County, this State, upon the small trees planted and growing on "tree claims." A Mr. Copeland tells me of several instances where parties who had planted ash trees failed in proving up on their claims on account of the ravages of this insect. About equally destructive and by far much more numerous is the larvæ of the Ash Saw-fly (*Monophadnus barda*, Say). This insect also infests the same district, where it also kills many trees by repeatedly stripping them of their foliage. The larvæ of this Saw-fly are whitish and feed in company in a similar manner to that of several other species. I have seen upwards of a dozen of them upon the upper surface of a single leaf.

Kerosene emulsion would be an effectual remedy against both of these insects.

I have for several years past noticed that some insect works in the seeds of our ash trees often to such an extent that fully half of the seed upon a tree has been injured. This, in a wooded country, would be of but little or no importance. Out here, however, where we depend upon the few natural groves that are growing along our streams to furnish seeds for the planting of the thousands of tree claims scattered over our treeless prairies, we soon discover the loss of seed. The present summer I found the two weevils *Thysanocnemis helvolus* and *T. fraxini* to be the depredators.

Another insect which appears to be greatly on the increase in Nebraska is *Datana angusii*, G. and R., known out here as the Walnut Caterpillar. This insect has for the past four or five years been more or less injurious to our planted groves of black walnut. This year, however, it was quite abundant, and at three or four places completely defoliated a large per cent. of the trees. On father's place, adjoining town, there were at least 50 trees thus stripped. The first worms appear sometimes during the early part of July, and from that time on until the beginning of October. Whether there are more than a single brood each year, or whether their appearance is irregular, I can not say. Unlike some of the other species of the genus, this insect appears to be remarkably free from the attacks of parasites of all kinds. At least this has been my experience with it, never having found a single larva that showed any signs of being parasitized. The only birds that I ever saw eating it were the Cuckoos, both the yellow and black-billed species.

Where the trees are not too tall, and time allows, hand-picking will answer admirably in disposing of this and allied species. During the third to last molts the larvæ congregate on the trunk and can be easily taken, their black bodies clothed with the scattered long white hairs, making them quite prominent objects whether in the foliage or upon the bark of the tree. Their gregarious habit also renders them more conspicuous and the more readily observed on account of their taking the foliage clean as they go.

The Honey Locust, which is used as a hedge-tree in portions of Nebraska, suffers greatly while yet small from the attacks of the gray Blister-beetle (*Lytta cinerea*). I have seen the trees defoliated in a few days. This present year but little injury occurred in the immediate vicinity of West Point, but up in Holt County trees that were set out last year were completely denuded, the beetles in some instances almost covering the entire tree, so numerous were they.

This tree also suffers greatly from the attacks of a Tortricid, the larvæ of which spins together several leaves at night and feeds upon the adjoining ones. This insect, too, occasionally becomes sufficiently numerous to defoliate trees. Last year a piece of hedge, here at West Point, over 100 feet in length, suffered in this respect.

THE AMERICAN CIMBEX.

(*Cimbex americana.*)

This large slug-like larva feeds upon the White Willow, usually used for a hedge tree and wind-breaks about buildings. A few years ago I first noticed it in injurious numbers on the hedges of Willow in Dodge County, about 16 miles southwest of here. This summer again I was surprised to see it in very many new localities, both in this and Dodge Counties. It always appears upon rather elevated ground back from the Elkhorn and tributaries.

Referring to my notes of July 22 in reference to this insect I find the following: "To-day I visited several localities only to find at least one-half of the larvæ matured and transformed. In scraping away the leaves and other vegetable débris from underneath the trees it was found that the grubs invariably sought the sheltered or sunny side of the hedge before spinning in. They also appear to be gregarious in this stage, always congregating into groups of from two or three to two dozen or more. Their transformation takes place only one-half or three-fourths of an inch below the surface."

Out of upwards of 400 pupæ that I collected I failed thus far to rear a single parasite. Of course these, if there are any, may not mature until next spring at the time when the imagos of the Saw-flies issue. Birds do not appear to feed upon them, neither will domestic fowls.

As a remedy against their rapid increase I would suggest the clearing away of all rubbish from beneath the hedge soon after the last worms have disappeared. This can be done with an ordinary garden rake. The rubbish should then be burned. A good method would be the supplying of an artificial retreat for the larvæ, composed of finely-cut or broken straw as a mulching, which could be easily removed and afterwards burned.

This insect has always occurred here in moderate numbers upon the willows growing along the smaller streams; and upon the introduction of the planted trees with the more favorable retreats has succeeded in becoming numerous and at the same time one of our dreaded insect enemies.

OTHER INSECTS.

Besides the above-named insects, the willows and cottonwoods in this and adjoining States suffer greatly from the continued attacks of the Striped Cottonwood Beetle (*Plagiodera scripta*). This beetle was again exceedingly numerous and destructive in this and several other counties in this portion of the State. While large trees and those on low ground seldom suffer greatly from their attacks, small trees, and especially those growing upon elevated grounds away from streams, are often killed by them.

Their natural enemies are chiefly those that are known to destroy the Colorado Potato Beetle (*D. 10-lineata*). Among these enemies the various species of Lady-birds are chief.

Several species of *Chrysomela* and *Disonycha* have also been quite numerous during the season just passed. These worked upon the foliage of several kinds of willow growing along the Elkhorn. They also were sufficiently numerous in many isolated localities to entirely defoliate the trees.

Last, but not least to be dreaded, is the Strawberry Crown-borer (*Tyloderma fragariæ*, Riley). This insect has been gradually on the increase throughout eastern Nebraska during the past few years, until now it has come to be recognized as one of our insect enemies. It not only attacks the tame varieties, but also works upon the wild vines. During the past summer I noticed it at work in a number of strawberry beds in this immediate vicinity, in one instance almost entirely destroying a large bed of several thousand plants, which the owner thought resulted from drought alone. It chose the Wilson in preference to the Crescent Seedling upon which to work, at least three times as many of the former than of the latter being destroyed.

There were many other insects belonging to the various orders that were observed to injure crops and useful vegetation. These, however, were in rather limited numbers and their injuries of comparatively little importance, and I do not think it necessary to make mention of them at the present time.

REPORT ON EXPERIMENTS IN APICULTURE.

By N. W. McLain, *Apicultural Agent.*

DECEMBER 31, 1887.

SIR: I have the honor to submit herewith my report of the work done under your instructions at this experiment station during the past year, the main features of which consist of a further prosecution of those lines of research begun in the year 1886.

I desire to acknowledge my obligations to yourself for the helpful assistance and encouragement you have given me while prosecuting my work under most discouraging circumstances; reference being had to the unparalleled climatic conditions prevailing throughout this region during the past year, and also to the altogether inadequate financial resources available for the uses of the station.

I wish also to thankfully acknowledge the valuable services and suggestions of those who have aided willingly in some lines of investigation, as well as the uniformly kind and appreciative mention of my efforts by those in whose behalf the work is being done.

It is further a pleasant duty for me to acquaint you with the fact that the Bee-Keepers' Association of North America, as well as some of the State bee-keepers' associations, have passed resolutions thanking in appropriate terms the honorable Commissioner of Agriculture and yourself for the deep interest you have manifested in advancing and developing the industry of bee-keeping.

I am also under continued obligations to the publishers of many apicultural and agricultural journals for the favor shown in publishing my reports, and for files of their valuable papers, among which I would mention:

The American Bee Journal, Messrs. Thomas G. Newman & Son, Chicago, Ill.; Gleanings in Bee Culture, Mr. A. I. Root, Medina, Ohio; The American Apiculturist, Mr. Henry Alley, Wenham, Mass.; The Canadian Bee Journal, The D. A. Jones Company, Beeton, Ontario; The Bee-Keeper's Guide, Mr. A. G. Hill, Kendallville, Ind.; The Bee-Keeper's Magazine, Messrs. Aspinwall & Treadwell, Barrytown-on-Hudson, N. Y.; The Bee-Keeper's Advance, Messrs. Mason & Sons, Mechanics Falls, Me.; The Cultivator and Country Gentleman, Messrs. L. Tucker & Son, Albany, N. Y.; The Southern Cultivator, Atlanta, Ga.; The Canadian Honey Producer, Mr. B. Holterman, Brantford, Ontario, Canada, etc.

Yours, very truly,

N. W. McLain.

Dr. C. V. Riley,
U. S. Entomologist.

DISEASES OF BEES.

The study of some forms of disease to which bees are subject, including an inquiry into the causes of disease, and the discovery and application of suitable remedies, has occupied much time, and the results from this line of investigation have been in a good degree successful and satisfactory.

The excellent classification and complete history which have been given of the micro-parasitical forms which affect the life and health of bees simplify diagnosis and facilitate the discovery and application of preventives and cures. Modern science has shown that it is often necessary to unlearn much of what was supposed to have passed beyond the region of doubt. The subject in hand furnishes no exception. It is not strange that there should be confusion and error in dealing with the origin and habits of these micro-organisms which baffle the skill of the investigator. We are now collecting and tabulating data and testing theories in the crucible of experience, and while our investigations are incomplete and many seemingly determined facts lack full confirmation, and while significant manifestations await interpretation, we must be slow in reaching conclusions. We may indeed be in the region of the knowledge we seek after, but we must hold the evidence under survey until many-sided experience fully determines its value.

Bacillus alvei (Cheshire).

This disease, commonly but inappropriately called foul-brood, is indigenous in all parts of the United States, and is infectious and virulent to the last degree. Concerning the origin of *Bacillus* and other allied organisms but little is certainly known, but that the organism classified as *Bacillus alvei* is the active agent in the destruction of both bees and brood is certain, for this agent is always present, and although its action in the living organism is exceedingly complicated it is also well defined.

The symptoms of this disease may be more clearly described by contrasting the appearance of bees' brood and combs in a healthy colony with the diagnostic symptoms attending *Bacillus alvei.* The bees act as if discontented and discouraged; the combs commonly present a dingy, neglected, and untidy appearance, and a characteristic odor is present, sometimes not noticeable until the hive-cover is removed, at other times offensive at some distance from the hive. This odor is very like that emitted from glue which has been prepared for use, then put aside and allowed to ferment. Instead of the plump, white, smooth appearance common to healthy uncapped larvæ, the membranes more or less wrinkled and shrunken, are streaked with yellow, which with the succeeding stages of disease changes into a dingy gray brown; then as putrefaction follows the color becomes a dirty red-brown. As evaporation progresses the mass settles to the lower side of the cell, and if the head of a pin be drawn through the mass, that which adheres appears quite stringy and elastic, the tracheæ and tougher tissues resisting decay adhering to the cell. Later nothing remains but a black, flat scale on the lower side near the bottom of the cell. If the disease does not assume the acute form before the pupa stage the brood is

capped over, but the cell cap, commonly of a darker color than that covering a healthy brood, settles, leaving the cover concave instead of flat or convex, and shortly small holes appear, as if inquiry had been instituted to learn the condition of the occupant, or to liberate the gases and odor and facilitate evaporation. Torn and ragged cell caps are frequent, and some cells may be empty and cleansed; and in the midst of ragged and sunken caps a live bee may occasionally emerge.

The means by which these deadly agents are commonly introduced into the hive and into the bodies of their victims has not been certainly determined. Prof. Frank R. Cheshire, F. L. S., F. R. M. S., to whom we are indebted for the classification of this species of *Bacillus*, and also for much that is valuable concerning its life history and pathogenic character, speaking of the means of propagating this disease, says (see Bees and Bee-Keeping, vol. 2, pp. 157, 158, London, 1888):

"My strong opinion is, that commonly neither honey nor pollen carry the disease, but that the feet and antennæ of the bees usually do." "It is also extremely likely that spores are carried in the air and taken in by the indraft set up by the fanners. There will be no difficulty in this supposition when it is remembered that the organisms are so minute that a cubic inch of material would form a quadruple line of them from London to New York."

My own experience and observation is in agreement with this last proposition, as witness the following paragraph from my report of last year (see Report of U. S. Entomologist, 1886, p. 587):

"That the contagion may sometimes be borne from hive to hive by the wind appears to be true, as it was observed in one of the apiaries which I treated for this disease during the past summer that of a large number of diseased colonies in the apiary, with the exception of two colonies all were located to the northeast of the colony in which the disease first appeared. The prevailing wind had been from the southwest."

Mr. Cheshire says further, page as above: "The bee-keeper is unfortunately almost compelled to become himself a probable cause of infection. His hands, made adhesive by propolis, carry the spores or bacilli, and so may transfer them, even hours later, to healthy hives. The clothes should be kept as far as practicable from contact with suffering colonies, and the hands after manipulating them should be disinfected by washing with a weak solution of mercuric chloride (corrosive sublimate), one-eighth of an ounce in 1 gallon of water being quite strong enough."

The concluding paragraph under this heading in my report for 1886 is as follows:

"That the disease germs may be carried upon the clothing and hands appears probable, from the fact that in one neighborhood this disease appeared in only two apiaries, the owners of which had spent some time working among diseased colonies at some distance from home, while other apiarists in that locality who had kept away from the contagion had no trouble from foul-brood."

It has been the common belief that honey is the medium through which the disease is most frequently introduced from both near at hand and remote sources of infection. That undue importance has been attached to honey as the common source of infection appears certain, for I have proved by repeated trials that if frames containing combs of capped honey, and having no cells containing pollen, be removed from infected hives and thoroughly sprayed or immersed, using an acid and alkaline solution of suitable strength to destroy the germs exposed to its action, the honey in such combs did not communicate disease when placed in healthy colonies and consumed by the bees as food for both summer and winter uses. I have found it altogether practicable to feed honey which had been extracted from infested combs without boiling, always adding, however, as a precaution, a disinfectant suitable to destroy any infection possibly lurking in such food.

In speaking of honey as a means of carrying this contagion, Mr. Cheshire says: "I have searched most carefully in honey in contiguity with cells holding dead larvæ; have examined samples from stocks dying out with rottenness; inspected extracted honey from terribly diseased colonies, and yet in no instance have I found an active bacillus, and never have been able to be sure of discovering one in the spore condition, although it must be admitted that the problem has its microscopic difficulties, because the stains used to make the bacilli apparent attach themselves very strongly to all pollen grains and parts thereof, and somewhat interfere with examination. I have now discovered that it is impossible for bacilli to multiply in honey, because they can not grow in any fluid having an acid reaction."

As to pollen being the medium by which this contagion is commonly introduced into the hive, not wishing to appear as speaking *ex cathedra*, I venture to say that further experiments in the line indicated in my report of last year leave little room to doubt the accuracy of the opinion then formed, namely, that pollen is the medium by which this contagion is most commonly introduced, and most rapidly

spread and persistently perpetuated. Continued observation showed that in those colonies where the largest quantity of pollen was being gathered the disease quickly assumed the malignant form, even when the quantity of brood was not greater than that being reared in other colonies where but little pollen was being gathered and in which the disease was far less virulent; and in this latter kind, where little pollen was being gathered, the contagion yielded most readily to treatment. But what seemed more to the point was, that from those colonies from which the combs containing pollen were removed and a suitable substitute furnished in the hive, thus avoiding the necessity for bringing supplies from the fields, the disorder was cured and the colony speedily regained their normal condition. The fact that queen larvæ seldom die from this contagion, taken in connection with what we know to be true concerning the character of their food, is significant, namely, that it is wholly composed of digested material, pollen grains being rarely found therein, and then as if present by accident and not by design, seems to justify the conclusion that the absence of pollen accounts for the absence of bacilli; while on the contrary the food of worker larvæ, secreted in excessive quantity and deposited in haste, occasional grains of pollen being dropped and no reason for their removal existing, the bacilli finding congenial cultures, multiply apace; and if perchance the larvæ escape infection, as is commonly the case until near the time of weaning, then live pollen being supplied, speedy and complete ruin results. Moreover, few if any bacilli are to be found in the chyle stomach of an adult queen at the head of a stricken colony, subsisted, as she must be, almost entirely upon secreted food produced by the worker bees: while in the chyle stomach of the worker, which partakes freely of pollen, they are present in quantity, and in fact line the whole intestinal tract.

The evidence presented in support of this pollen theory of the means of introducing and spreading this contagion is circumstantial, still it is component; and if it fails to reveal the true source of infection, the fact that the consumption of such live pollen as is obtained from the fields during the prevalence of this disease, or such old pollen as is stored in cells in which it may have molded or rotted and become a possible source of infection, aggravates the disease and makes it more persistent, and the fact that if the old pollen be removed from the hive and artificial pollen be substituted the malignant and persistent characteristics disappear, and that the contagion then readily yields to suitable treatment, is settled beyond question.

While it is true that queen bees have less to fear from infection in the larval stage, it is also true that queens reared in infested colonies are commonly worthless. Of twenty-five queens so reared in one apiary and successfully established at the head of as many colonies, not one survived the period of hibernation. In case the contagion does not assume the acute form in the larvæ it may localize and become chronic, and so, the bacillus of disease being as unnatural as disease itself, both worker and queen may live on for weeks and months, and the queen, with both life and death within her, transmitting the possibilities of both. Mr. Cheshire has counted as many as nine bacilli in a single egg, a discovery full of significance when striving to account for the spread of disease. It is but natural that this contagion, being a disease of the blood, should find congenial and luxuriant feeding-ground among the most delicate and highly organized glands and tubes of the ovaries.

We may reason thus: The bee-pap furnished to the queen larva, the protoplastic egg-food, copiously furnished to the queen during the breeding season, is continuous and passes from cell to cell. The germ cell of bacillus contributed to the organism of the queen in larval or in egg-food, borne along through the digestive and circulatory system, passes within the ovarian tubes and from thence into the nascent egg-cell, and once within the yolk is ready to contend for supremacy against the spermatozoid soon to be introduced. But the strife is unequal, and instead of the differentiating principle determining the form, function, and instinct of a new creature appointed to long life and service, the bacillus, finding the environment suited to multiplication, sterilizes the blood and riddles the tissues and viscera.

The remedy which I have found to be a specific—by the use of which I have cured hundreds of cases, many of which seemed hopelessy incurable, without failure and without a return of the contagion, except in the case of two colonies of black bees, where the disease reappeared in a form so mild that each colony was speedily cured, each one casting a swarm and making a fair amount of surplus honey—is prepared and applied substantially as directed in my last annual report.

In 3 pints of warm soft water dissolve 1 pint of dairy salt. Add 1 pint of water, boiling hot, in which has been dissolved four tablespoonsful of bicarbonate of soda. Dissolve one-quarter ounce of pure salicylic acid (the crystal) in 1 ounce of alcohol.

Add this to the salt and soda mixture, then raise the temperature near to the boiling point, and stir thoroughly while adding honey or sirup sufficient to make the mixture quite sweet, but not enough to perceptably thicken, and leave standing for two or three hours, when it is ready for use. An earthen vessel is best. I have tried other acids and alkalies in other forms, but the remedy prepared as directed and applied warm is that which I prefer.

Treatment.—Upon removing the cover from the hive thoroughly dampen the tops of the frames and as many bees as are exposed by blowing a copious spray of the mixture from a large atomizer. Beginning with the outside, lift a frame from the hive and throw a copious spray over the adhering bees on both sides of the comb, shake off part of the bees into the hive, and spray those remaining; then shake and brush these into the hive; then blow a copious spray of the warm mixture over and into the cells on both sides of the combs sufficient to perceptibly dampen both comb and frame. In like manner treat all the frames, seriatim, returning them to the hive in order. From combs containing very much pollen the honey should be extracted and the combs melted into wax. This extracted honey may be fed with safety, 2½ ounces of the remedy being added and well stirred into each quart of honey.

All the colonies in the apiary should be given a thorough spraying the first time the treatment is applied, but combs containing pollen need not be removed from healthy colonies. After the first thorough treatment the combs and bees should be thoroughly sprayed with the remedy at intervals of two or three days until cured. Three treatments after the first thorough application are commonly sufficient. First one frame being lifted from the hive and sprayed and the others simply set apart, so that the spray may be well directed over and copiously applied to both bees and combs. An essential feature in my method of treatment, which I failed to make duly significant and prominent in my last annual report, is that medicated honey or sugar sirup should be continuously fed to all infected colonies while they are convalescing, for not only must the contagion be driven from the organism of the adult bee and suitable food and tonic given to aid in repairing the ravages of disease, but a constant and even supply of the remedy serves as a preventive and cure for the larvæ.

The honey or sirup should be fed warm, and two ounces of the remedy should be well mixed in each quart of food, which may be given in feeders or by pouring over and into empty combs and placing these in the hive.

To prevent the bees from going abroad for supplies. make a thin paste of rye flour and bone flour, three parts of the former to one of the latter, adding the medicated honey or sirup. Spread this over a small area of old comb and honey in the hive, or feed in shallow pans or wooden butter dishes in the top of the hive or outside in the apiary, under shelter from rain. I prepare the bone flour by burning dry bones to a white ash. The softest and whitest pieces I grind to dust in a mortar and sift through a very fine sieve made of fine wire-strainer cloth. The coarser pieces of burned bone I put in open vessels with lumps of rock salt, which I keep half covered with sweetened water and sheltered from the rain, at all times accessible to the bees. The rapidity with which depleted colonies recuperate and become populous is surprising. I have tried supplying the saline, alkaline, and phosphate elements in bee food by using boracic acid, phosphoric acid, etc., but I find that the bees take kindly to the supplies prepared as I have directed, and the amount consumed shows their appreciation and need. Such supplies of food and drink should be kept at all times in the apiary, easy of access. I have not found disinfecting of the hives necessary further than to simply dampen the inside with a copious spray of the remedy, and sometimes no care was taken to do even this.

Starved Brood.

A disorder which has been quite common in several States during the past season is resultant from conditions prevalent during severe and protracted droughts, and long periods of extremely high temperature, such as has existed over large areas.

The disorder is significant and important, not so much on account of the actual numerical loss entailed upon colonies affected, which in my own case and in many cases reported to me have been severe, as in furnishing proof of failure on the part of those food elements indispensable during the breeding season to meet the large demand for larval food and essential in maintaining the health and vigor of the bees while the digestive and secretory organs are being taxed to the limit of their capacity. This failure of natural resources results in low vitality, susceptibility and predisposition to disease, and inability to successfully perform the function of hibernation. With some exceptions, due to local advantages, throughout the States stricken by the drought of the past summer the bees have entered upon the period of

hibernation under conditions more or less unfavorable in proportion as they have suffered in greater or less degree from the effects of the all-consuming drought and heat.

The symptoms of starved brood are distinctively characteristic. Upon opening the hive a slightly offensive odor may be noticed if the colony has been suffering for some time. If the comb-frame be lifted from the hive and the bees shaken off few if any eggs can be found. Of such brood as is sealed the cappings appear to be thin and flat and slightly sunken, and commonly of darker color than is usual in prosperous colonies. Upon opening the cells they are found to contain dead pupæ in various stages of development, always inferior in size, and the food supply exhausted. In the midst of sealed brood patches of uncapped larvæ appear, and sometimes a patch of 5 or 6 inches square, and sometimes there seems to have been no effort made towards sealing half the grown larvæ in the hive, although the time for such sealing may be far overdue. The membranes of such larvæ do not present the plump pearly-white appearance common to well-fed larvæ. On the contrary, the membranes are more or less shrunken and wrinkled, and not unfrequently, when the larvæ have reached the advanced pupa stage, the compound eyes begin to color and the cells are partially capped and then abandoned, and the appearance is that commonly designated by the term "bald-headed bees." Sometimes a few of these bees, dwarfed in size, emerge from the cells and engage in the labors of the hive with what vigor and for such term as their limited development will permit. In a number of tests made during the past season the progeny of the same queen, reared under directly opposite conditions of larval growth, so varied in size as not to be recognizable as offspring of the same progenitors. The reason for this variation was not far to seek. The changed conditions of the colony during the time when the different generations were being reared determined the modification in development. The remedy I used and prescribed for others was preventive rather than curative. Starved brood means starved bees. If the cause be removed the effect speedily disappears. All that needs to be done is to supply them with a substitute for those resources essential to their own health and vigor and indispensable in brood-rearing, in search of which they are rapidly and vainly wearing out their vitality.

The recipe for preparing the remedy is as follows:

To 10 pounds of sugar add half a pint of dairy salt, 2 table-spoonsful bicarbonate of soda, 2 table-spoonsful rye flour, 2 table-spoonsful very finely powdered bone ash, and 1 table-spoonful cream tartar. Mix thoroughly, then add 2 quarts hot water, and stir until thoroughly dissolved, then boil for two or three minutes only. To one-half pint fresh milk add 3 fresh eggs thoroughly beaten, and when the sirup is cool enough to feed add the eggs and milk, and when thoroughly stirred feed warm. Feed in the hive as one would feed honey or sirup.

I used this same food for preventing spring dwindling and for building up colonies to full strength and efficiency, so that all colonies may be ready for work at the very beginning of the season when surplus honey may naturally be expected. This food fed in the hive keeps all the bees at home to aid in performing the functions of brood-rearing and in keeping up the temperature of the hive instead of spending their little remaining strength in battling against the cold, damp winds while searching for the food elements needed to repair the waste and drain upon their vitality while hibernating, and indispensable in brood-rearing. This food is not intended for use until after the bees have had a good flight in spring and almost any grade of honey or sugar may be used. This special food is a potent stimulant and tonic to the adult bees, giving tone and vigor to the organism, and furnishes the elements essential in brood-rearing in the place and in the manner suited to the convenience and tastes of the bees. No greater quantity should be fed than is required for the current needs of the colony.

THE CONTROL OF REPRODUCTION.

In order that the laws of heredity and the active principles of selection may be practically and persistently applied in the breeding of bees, I have in obedience to your instructions continued my experiments, striving to discover a simple and practical method for securing control of the natural process of reproduction.

I devised and constructed a fixture, which I call a fertilizing cage, 22 feet square and 26 feet high. Selecting a level plot of ground I set 4 rows of posts, 4 posts in each row, forming a quadrangle. These posts are 4 inches square and 30 feet in length, set into the ground 4 feet and exactly 7 feet apart. Four rows of girders, 2 by 4 inches by 22 feet 4 inches are halved in two and bolted to the inside of these posts, the first row 5 feet from the ground, then three rows at intervals of seven feet until the top is reached. The upper 3 lines of girders are continued from each side of each

inside post, forming a brace on each side of each post at intervals of 7 feet, and forming the bearings for the wire-covered frames which cover the top of the cage. The space from the ground to the first girder, 5 feet, is covered with matched lumber nailed to the outside of the posts, leaving a smooth surface on both sides. The upper 21 feet on the sides and the top of the cage is inclosed by wire-covered frames 7 feet square, bolted to the girders on the sides and securely fastened with screws to the frame-work at the top. The height of the cage is thus adjustable at 26 feet, 19 feet, or 12 feet from the ground by simply lowering the screen frames forming the top, and the upper row (or two upper rows as the case may be) forming the sides of the inclosure, the purpose being not only to determine whether queens or drones would mate in this cage at full size, but also how small an inclosure would be sufficiently large to give suitable freedom and range of flight.

These wire-covered frames are framed like a two-light window-sash, with a mullion in the center, on which the two breadths of wire-cloth meet. Strips of wood secure the edges of the cloth and cover all joints at the sides of the frames. With the lower board of the siding settled into the ground and earth filled against the inside and the door tight-fitting the cage is bee-tight. I used drab-colored wire cloth, which obstructs the light but very slightly. A shelf is fitted against the four sides of the cage on the inside 1 foot from the ground and alighting boards directly opposite on the outside. Upon this shelf the hives are placed. Each hive has an exit cut in either end and an exit is cut through the wall of the cage registering with the outer exit of each hive, over which, on the outside of the wall, a piece of queen-excluding zinc is nailed. These hives are painted strikingly distinguishing colors, as red, white, blue, green, yellow, and black, and a space opposite each on the alighting boards and a corresponding space on the outside of the wall of the cage are painted in corresponding colors. The colors are repeated in the order named, which separates the hives of the same color a sufficient distance to prevent confusion, and bees and queens readily distinguish their own hive by means of color as readily as by location. If the inner exit be left closed for a day or two after a colony is placed in a cage the worker bees readily learn to enter their own hive upon returning from the fields. I found that the queens had no difficulty on returning to their own hives after taking flight in the cage. To test that fact I frequently opened a number of hives in succession and placing the queens upon the palm of my hand tossed them high in the air, when they would take wing and fly away. Upon re-opening the hives a few minutes later they would be found upon the combs. The queens and drones appeared to fly and disport themselves with as much freedom and regularity in the cage as they did in the apiary outside. The virgin queens were introduced from the nursery by various methods. Some were hatched in colonies in the cage from cells matured in strong queenless colonies and some from cells built under the swarming impulse, which this season could be produced by artificial means only. Mature drones were selected from the hives in the apiary and also from those returning from their excursions and liberated in the cage, and sealed drone-brood was removed from hives in the apiary and hatched in strong colonies built up in large hives in the cage, and these drones all flew with freedom and regularity. A few times I observed a queen embrace a drone and fly all about the cage with entire freedom, and then, the embrace being broken, each flew away in different directions, the queens returning to their hives and the drones at once rejoined their fellows in the upper part of the cage. It is needless to add that in such cases no accouplement had taken place.

The results realized from this line of experimental work have been so meager and the circumstances attending the experiments so exceptionally unfavorable that it is not easy to form an estimate of their value or determine their significance. Of the many scores of trials made but six were successful; but six queens were fecundated in the fertilizing cage. However, as the improvement of the bee to the highest attainable excellence outranks all other considerations in practical importance and scientific interest, the methods and results of any intelligently-conducted experiments having this end in view are well worth placing on record. Besides future trials may receive direction from a multitude of failures and the trying experience of the past season is not without compensating features, for even the little gains we make in positive knowledge, although apparently trifling in themselves, have often significant meaning and broad bearing on questions of great value.

My experience and observation lead me to believe that the main reason why this experiment was not satisfactorily successful was because of the protracted drought and high temperature which lasted through the entire breeding season, the like of which has not before been known in this region. From May, 1886, until December, 1887, drought prevailed, broken only at long intervals by light showers. The succession of two summers of excessive heat and unbroken drought insured disaster to the present season cumulative in kind and intensified in degree. Continuous

feeding has been required to keep up breeding and to prevent starvation. Whenever feeding was suspended for two or three days, throughout nearly the entire season, oviposition would cease and the bees ate their eggs, and it has required persistent trials and careful management to rear drones and keep them alive. It has been difficult to get three or four queen cells matured in colonies such as in ordinary seasons would rear from twenty-five to forty, and of those permitted to remain outside in the apiary and seek a mate at will two of every three failed of fecundation. During the entire season a large majority of the larval queens, being insufficiently fed, died in the cell, and when for days and weeks together the temperature ranged from 110° to 120° F. in the sun during several hours each day the pap-food would ferment and turn a dark amber color and dry up to the consistency of thick glue at the bottom of the cells with the dead pupæ. When the temperature ranged from 100° to 110° F. in the sun the average temperature in the hive was from 5° to 2° higher until 112° was reached. Then, when the range in the sun was from 115° to 125° the temperature did not go above 112° in the hive. The fanners were able to prevent the temperature rising above 112° in hives standing in the sun with a shade-board above the hive-cover. The worker larvæ seem to be able to endure a higher temperature than queen larvæ. This season, as a rule, the drones were much smaller than drones from the same ancestors in the summers of 1885 and 1886, and there was a great inequality in the size of drones and queens of the same parentage and reared at the same time in the same hive, and a very unusual proportion of the queens were deformed and unable to fly.

Continued observation and experiment furnish corroborative evidence of the correctness of the theory advanced in my last annual report, namely, that drone bees differ in degrees of procreativeness, properly classified as the impotent, the conditionally potent, and the potent; and that it is the prerogative of the worker bees to determine the degree of development and dominate the function of the drones as they determine the kind and degree of development of instinct and organism and dominate the functions of the queen. The volition of the queen determines the sex of every one of her descendants; but the life of every individual as well as the modifications in organism and instinct depends upon and receives its direction from the worker bees, whose unerring prescience forbids the rearing or maintaining of individuals for whose services there exists no present or prospective demand. It is only when this keen apprehension of the present and prospective conditions of environment indicates a necessity for rearing and maturing potent or potentially potent individuals that such are reared and matured and furnished for the functions they are to perform. Under circumstances unfavorable in the extreme a condition of seeming prosperity may be artificially produced, and drones numerically plentiful may be reared and preserved alive. It has taxed my skill and patience to the last degree during the past season to do this. I resorted to every strategem I could devise to secure a supply of mature drones, but in most cases the workers were either unable or unwilling to supply the drone larvæ with food suitable in kind and quantity, for a large proportion of the drones were dwarfed. Dissection showed the sex organs of this sort to be inferior in size, dry, and empty. Not one drone in one hundred of those which were fully developed, when held by the legs or wings or when pressed upon the thorax, were able to perform the expulsion act, and the sex organs of such, with rare exception, contained nothing but a little clear, thin mucous. I have during the past season at various times examined the contents of the sex organs from scores of drones well developed and structurally perfect of the class which I believe to be potentially potent, in which I have not been able to discover active spermatozoa, nor was the mucous secretion present of that color and consistency which I believe to be the product of special feeding and indispensable to sexual desire, and for liberating and floating the spermatozoa into the spermatheca.

Without wishing to appear dogmatic, after another season exceptionally favorable for such observation and experience as has furnished more complete data and corroborative evidence, I venture to reassert my belief as set forth substantially in my last annual report, that the preparation for and exercise of the reproductive faculty in drone bees, as well as in queens, depends upon and is determined by the workers. As with the queen so with the drone, desire and capacity wait upon the will and resources of the workers.

As the queen must be bountifully supplied with egg-food before the egg-cells begin to germinate and mature in the ovaries, so I believe the drone must be well supplied with that special food suited and intended to produce the desire and capacity for performing the act of copulation, the giving and withholding of which is instinctively determined by the worker bees as the present and prospective condition demands. Throughout the past season of extreme heat and protracted drought there was almost total failure of all natural resources, and all the influences of nature to

which bees are subject warned them that there was no actual necessity for feeding and maturing drones, and that the abundance and prosperity with which I had supplied them were artificial and deceptive. In the impotency of the drones, almost universally prevalent, I find the reason for the almost total failure of this experiment. The fact that both drones and queens flew with freedom and regularity in the cage, and the fact that in a few cases queens were successfully mated in the cage when but few were successfully mated outside leads me to believe that under favorable conditions satisfactory success may be expected. Experiments in breeding bees during the prevalence of such climatic conditions as those of the past season are attended with hindrances which I have not been able to overcome. My experience and observation have suggested some changes in the size, shape, and manner of constructing the cage which I believe would be an improvement. If, under favorable circumstances, the control of the process of reproduction can be secured by the use of a device permanent in kind and of moderate cost then every queen breeder and progressive bee-keeper may apply the laws of heredity and the principles of selection to the breeding of bees with assurance of realizing results alike in kind and degree to those which have by the persistent application of the same laws and principles been realized in breeding all kinds of domestic animals.

I have, by establishing mating stations in localities remote from other bees, secured the mating of queens and drones selected on account of their excellent paternity and perfect development. I controlled the flight of the different varieties by the use of queen-excluding zinc. By crossing selected individuals of different varieties, and by mating selected bees of the same variety avoided in breeding, I have laid the foundation for some ancestral stock of superior excellence. This kind of work requires much patience and persistence during such a season as that just ended. I have begun many other experiments, many of which failed, and others, lacking in completion, require no mention here.

EXPLANATION TO PLATES TO REPORT OF ENTOMOLOGIST.

Where figures are enlarged the natural sizes are indicated in hair-lines at side, unless already indicated in some other way on the plate.

EXPLANATION TO PLATE I.

THE CHINCH BUG.

(Original.)

FIG. 1.—Stalk of wheat showing Chinch Bugs at work—natural size.

FIG. 2.—The eggs, showing slight variation in color, and the terminal caps—greatly enlarged.

FIG. 3.—Larva of second age—greatly enlarged.

FIG. 4.—Larva of third age—greatly enlarged.

FIG. 5.—Pupa—greatly enlarged.

FIG. 6.—Adult insect, normal type—greatly enlarged.

FIG. 7.—Adult insect, ordinary short-winged form (Fitch's var. *apterus*)—greatly enlarged.

FIG. 8.—Adult insect, short-winged form from the sea-shore—greatly enlarged.

EXPLANATION TO PLATE II.

THE CODLING MOTH AND ITS PARASITES.

(Original, except fig. 5.)

FIG. 1.—Nearly full-grown larva, from side—enlarged.

FIG. 2.—Chrysalis from side—slightly enlarged.

FIG. 3.—Adult, from above, with expanded wings—slightly enlarged.

FIG. 4.—Adult, from above, wings closed—slightly enlarged.

FIG. 5.—Apple cut open, to show work of larva which has become full grown and issued: *a*, full-grown larva; *b*, moth at rest; *c*, the less common channel of exit through cheek of apple; *d*, the point where the egg was laid, showing original channel of entrance, afterwards enlarged for the purpose of pushing out excrement—all natural size (redrawn from Riley).

FIG. 6.—Apple oviposited in by second brood of moths, cut open, showing appearance before larva has reached half growth—natural size.

FIG. 7.—*Pimpla annulipes*, female—enlarged.

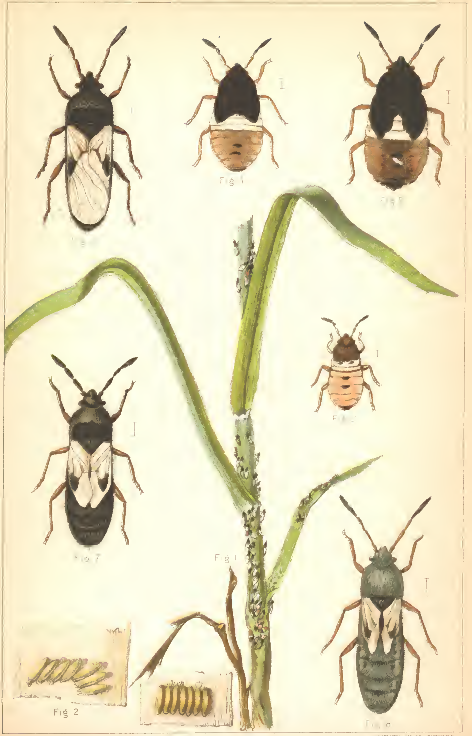
FIG. 8.—*Macrocentrus delicatus*, female—enlarged.

EXPLANATION TO PLATE III.

FIG. 1.—Immature stages of the Chinch Bug: *a*, *b*, eggs; *c*, newly-hatched larva—both greatly enlarged; *d*, its tarsus—still more enlarged; *e*, larva after first molt; *f*, same after second molt; *g*, pupa—all greatly enlarged; *h*. enlarged leg of adult; *j*, tarsus of same—still more enlarged; *i*, proboscis or beak—greatly enlarged (after Riley).

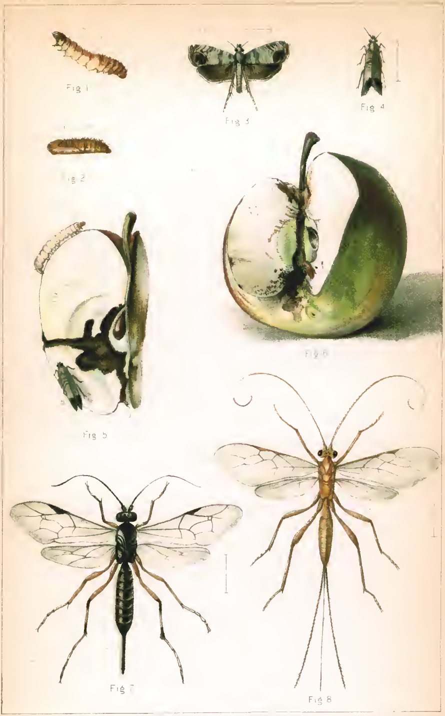
FIG. 2.—Adult Chinch Bug, short-winged variety—enlarged (after Riley).

FIG. 3.—Adult Chinch Bug, normal form—enlarged (after Riley).



L. SULLIVAN, DEL. ET PINX.

THE CHINCH BUG.



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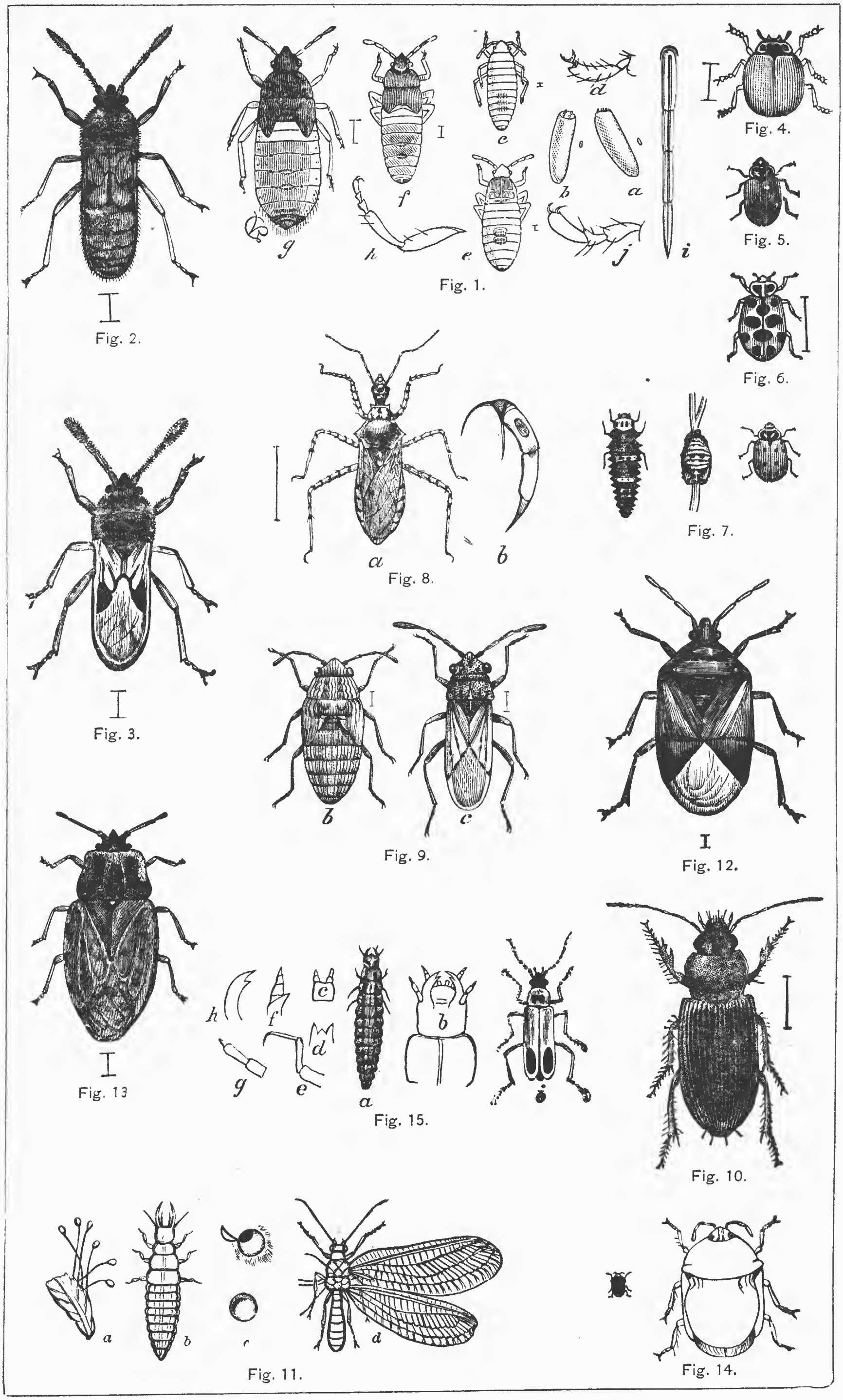
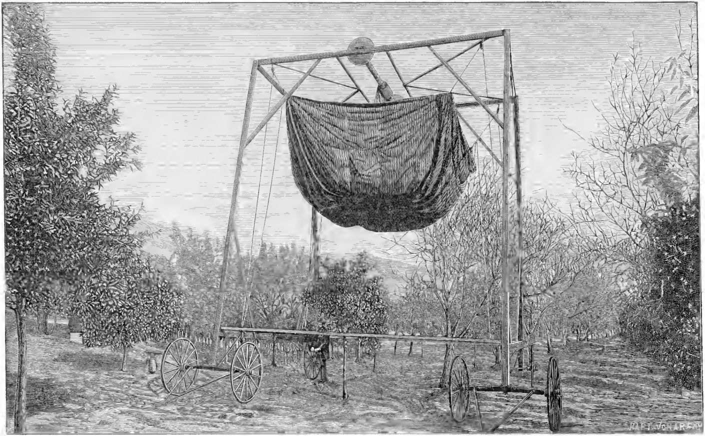
THE CODLING MOTH AND ITS PARASITES

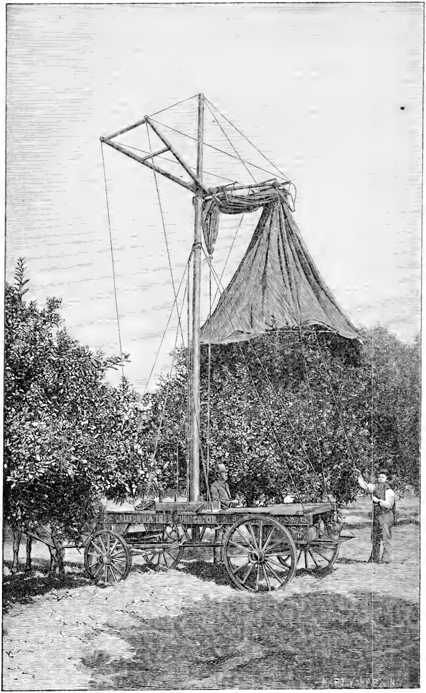


MISCELLANEOUS INSECTS.

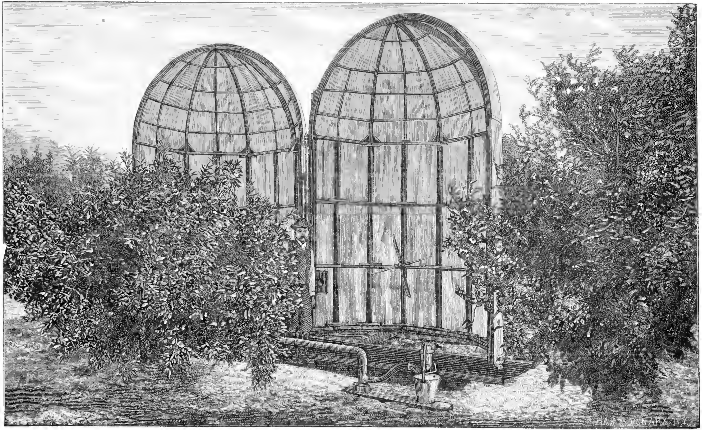
Report of the Entomologist, U. S. Department of Agriculture, 1887



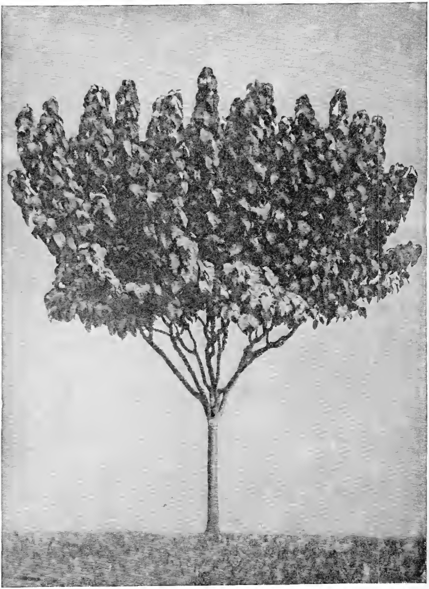
THE TITUS FUMIGATOR.



THE WOLFSKILL FUMIGATOR.



THE CULVER FUMIGATOR.



CATTANEO "PRIMITIVE" MULBERRY TREE EIGHT YEARS FROM THE SEED.

CATTANEO "PRIMITIVE" MULBERRY TREE, SHOWING METHODS OF PRUNING.

FIG. 4.—*Cycloneda sanguinea*, an enemy of the Chinch Bug—enlarged (after Riley).

FIG. 5.—*Hippodamia glacialis*, an enemy of the Chinch Bug—natural size.

FIG. 6.—*Hippodamia maculata*, an enemy of the Chinch Bug—enlarged.

FIG. 7.—*Hippodamia convergens*, an enemy of the Chinch Bug: *a*, larva; *b*, pupa; *c*, adult—all natural size (after Riley).

FIG. 8.—*Milyas cinctus*, an enemy of the Chinch Bug: *a*, adult bug—enlarged; *b*, its beak—still more enlarged (after Riley).

FIG. 9.—*Nysius angustatus*, frequently mistaken for the Chinch Bug: *b*, pupa; *c*, mature bug—enlarged (after Riley).

FIG. 10.—*Agonoderus pallipes*, an enemy of the Chinch Bug—enlarged (after Riley).

FIG. 11.—*Chrysopa plorabunda*, an enemy of the Chinch Bug: *a*, eggs; *b*, larva; *c*, cocoon; *d*, adult—all enlarged.

FIG. 12.—*Triphleps insidiosus*, an enemy of the Chinch Bug, frequently mistaken for it—enlarged.

FIG. 13.—*Piesma cinerea*, mistaken for Chinch Bug—enlarged (after Riley).

FIG. 14.—*Corimelæna pulicaria*, mistaken for Chinch Bug—enlarged (after Riley).

FIG. 15.—*Chauliognathus pennsylvanicus*, an enemy of the Codling Moth: *a*, larva, full grown—natural size; *b*, *c*, *d*, *e*, *f*, *g*, *h*, head parts—enlarged; *i*, adult beetle—natural size (after Riley).

EXPLANATION TO PLATE IV.

(Engraved from a photograph.)

The Titus fumigator—invented in California for the gas treatment of trees infested with Scale-insects.

EXPLANATION TO PLATE V.

(Engraved from a photograph.)

The Wolfskill fumigator—another device for the same purpose.

EXPLANATION TO PLATE VI.

(Engraved from a photograph.)

The Culver fumigator—another device for the same purpose.

EXPLANATION TO PLATE VII.

(Engraved from a photograph.)

Cattaneo "Primitive" Mulberry tree, eight years from the seed.

EXPLANATION TO PLATE VIII.

(Engraved from a photograph.)

Cattaneo "Primitive" Mulberry tree, showing methods of pruning.

REPORT OF THE CHEMIST.

I have the honor to submit herewith the report of the work done by the Chemical Division for the year 1887.

This work may be classified as follows: First, the continuation of the subject of investigations of food adulteration; second, investigations connected with the manufacture of sugar from sorghum and sugar-canes; third, studies of agricultural products; and, fourth, miscellaneous work. The investigation of adulterations has continued essentially in the same line as was pointed out in the annual report for 1886.

The chief object of investigation has been to determine the character of adulteration practiced and the best methods of detecting it. The work of determining the extent of adulteration is more properly left to the State experiment stations and State municipal boards of health. The results of the investigations are published in Bulletin 13 of the Chemical Division. In the last annual report abstracts of the first and second parts of this bulletin were given. They were devoted to dairy products and to spices and condiments. During the last year one additional part of Bulletin 13 has been issued on the subject of fermented drinks. In this bulletin the subjects of wines, beers, and ciders were considered. Two other parts of Bulletin 13 are now in an advanced state of preparation, viz, baking powders and lards.

The work on the investigation of the sugar-making qualities of sorghum and sugar-canes has been carried on at three different stations, viz, Rio Grande, N. J., Fort Scott, Kans., and Lawrence (Magnolia Plantation), La. The results of these investigations appear in Bulletin 17, already published, and Bulletin 18, now almost ready for the press. Those results mark a successful close of a long series of investigations undertaken by the department, which have been carried on under many difficulties and discouragements. The character of the work which has been accomplished will fully appear in the abstracts which are to follow.

The miscellaneous work of the department has been of a varied character, and it appears to me of little value. This miscellaneous work has consisted in analyses of samples of ores, mineral waters, soils, fertilizers, etc. It is true that quite a number of these investigations have proved of value in themselves, but they do not illustrate any line of methodical research, and thus fail to appear in their proper light. Abstracts of the more valuable work of this kind will follow. In regard to this miscellaneous work I desire to say that, with a limited force at our disposal and the meager laboratory facil-

ities which we have, it does not seem quite appropriate to ask of the division to undertake analyses which are purely for personal advantage or entirely disconnected with agriculture. I desire to plainly state that in my opinion the analyses of ores, mineral waters, and other substances which have no relation whatever to agricultural research are not proper subjects for the employment of the chemists of this division. In the same category should be placed examinations of soils, fertilizers, food stuffs, and other agricultural products sent from States where agricultural colleges and experiment stations have been established. Under the Hatch bill each State has been provided with a fund by Congress for the purpose of carrying on just such investigations as I have mentioned. This fund is in excess of the total amount which is given annually for the support of the distinctively chemical work of this division. In order that the investigations which this division has undertaken in the interest of agricultural chemistry may not be interrupted by such extraneous work it would be well to prohibit, by a clause in the appropriation bill, any work in the chemical division which is purely of a personal nature or not related to agricultural science, or which could be more properly done by the chemists of the several State agricultural colleges and experiment stations. This division would thus be relieved of the labor of examining minerals, ores, mineral waters, potable waters, and other substances of like nature.

There is another reason which leads me to emphasize this statement. We have in our country a large number of professional chemists who devote themselves to private work, and analyses of such samples as I have named naturally belong to this class of chemists. To have this work done by public officials, at public cost, is not only an abuse of official prerogative, but is a positive injury to a legitimate private business which, at best, is poorly supported in the United States. There is no more reason why the chemists employed by the United States to pursue investigations in agricultural science should determine the quantity of gold and silver in a given ore for a private citizen or a member of Congress than there would be for a law clerk of one of the Departments of the Government to devote his time and labor to private practice. This practice of doing private work at public expense it seems to me is of the same nature as that of doing private work during office hours and receiving compensation therefor from the individual for whom the work is done. Since I have been in charge of this division I have constantly refused all applications which have been made to have me or my assistants engage in private work of any kind for compensation during the hours devoted to official business. I would even go further than this and require, if possible, that chemists engaged in official work for the Government of the United States should not be allowed to engage in private work even out of official hours. The duties of a chemist engaged in official work are sufficiently onerous to require all his time and energy, and whatsoever is given to work of a private nature is so much taken from what he owes to the public. In short, in my opinion, the line of demarkation between official and private business should be sharply drawn and should never be transgressed. The compensation received by a public analyst or an official chemist should be large enough and his tenure of office sufficiently certain to enable him to devote all his time to the public service without being troubled with anxieties for the future.

Since the establishment of agricultural stations in the various States it may be asked, what is the peculiar function of the Chemical Division of the Department of Agriculture? Is this division only one of the many laboratories established in the several States under the Hatch bill, or has it a work peculiarly its own? I should answer the last question in the affirmative. The work of this division seems to me to be best illustrated by that line of investigation in the work which has been published on food adulteration, and through experimental studies of different methods of analysis and investigations of a more abstract nature intimately connected with the problems of practical agriculture. The study of great problems affecting large industries, like those which have been made in the sugar industry, and the examination of questions affecting proposed legislation on agricultural subjects for the benefit of the agricultural committees of the Senate and the House of Representatives are some further examples of the distinctions of the work of this division from that of the chemical laboratories of the various experiment stations. For a proper prosecution of work of this kind the Congress of the United States should supply a first-class laboratory with first-class appointments. The chemical laboratory of the United States Department of Agriculture should be a model which the various experiment stations might copy instead of being what it is, perhaps the most poorly located and equipped of any chemical laboratory in the country. In a dingy basement, poorly lighted, not ventilated at all, the chemists of this division are compelled to work, in the winter straining their eyes in an all-day twilight, in summer sweltering in a tropical temperature.

I would earnestly request that the bill which is now before Congress for the building and equipment of a new laboratory be pressed to an early passage, so that this division may be furnished with facilities to continue more successfully the line of work which has been marked out.

COMPOSITION OF AMERICAN BEERS, WINES, AND CIDERS, AND THE SUBSTANCES USED IN THEIR ADULTERATION.*

By C. A. CRAMPTON.

MALT LIQUORS.

The production of malt liquors in this country as an industry is second only in importance to the production of breadstuffs. Their consumption is steadily on the increase, as is also the amount consumed in proportion to other kinds of alcoholic beverages. The following tables are taken from recent statistics, compiled by the Bureau of Statistics, U. S. Treasury Department, from figures obtained from official sources: †

*Abstract of Part 3, Bull. No. 13.

† Statements Nos. 32 to 50, inclusive, of the Quarterly Report No. 2, series 1886–'87, of the Chief of the Bureau of Statistics. Government Printing Office, 1887.

Annual consumption of distilled and malt liquors and wines in the United States and the average annual consumption per capita of population during the years 1840, 1850, 1860, *and from* 1870 *to* 1886, *inclusive.*

Year ending June 30—	Distilled spirits consumed.				Wines consumed.		
	Spirits of domestic product.		Imported spirits entered for consumption.	Total.	Wines of domestic product.*	Imported wines entered for consumption.	Total.
	From fruit.	All other.					
	Pr. galls.	*Pr. galls.*	*Pr. galls.*	*Pr. galls.*	*Gallons.*	*Gallons.*	*Gallons.*
1840	(†)	40,378,090	2,682,794	43,060,884	124,734	4,748,362	4,873,096
1850	(†)	46,768,083	5,065,390	51,833,473	221,249	6,094,622	6,315,871
1860	(†)	83,904,258	6,064,393	89,968,651	1,860,008	9,199,133	11,059,141
1870	1,223,830	77,266,368	1,405,510	79,895,708	3,059,518	9,165,549	12,225,067
1871	2,472,011	59,842,617	1,745,033	64,059,661	4,980,783	10,853,280	15,834,063
1872	1,089,698	65,145,880	2,186,702	68,422,280	6,968,737	9,713,300	16,682,037
1873	2,965,987	62,945,154	2,125,998	68,037,139	8,953,285	9,893,746	18,847,031
1874	766,687	61,814,875	1,958,528	64,540,090	10,951,859	9,516,855	20,468,714
1875	1,757,202	62,668,709	1,694,647	66,120,558	12,954,961	7,036,369	19,991,330
1876	672,221	57,340,472	1,471,197	59,483,890	14,968,085	5,193,723	20,161,808
1877	1,527,141	57,016,248	1,376,729	59,920,118	16,942,592	4,933,738	21,876,330
1878	1,103,351	49,600,838	1,227,752	51,931,941	17,953,386	4,310,563	22,263,949
1879	1,021,708	52,003,467	1,253,300	54,278,475	19,845,113	4,532,017	24,377,130
1880	1,005,781	61,126,634	1,394,279	63,526,694	23,298,940	5,030,601	28,329,541
1881	1,701,206	67,426,000	1,479,875	70,607,081	18,931,819	5,231,106	24,162,925
1882	1,216,850	70,759,548	1,580,578	73,556,976	19,934,856	5,628,071	25,562,927
1883	1,253,278	75,508,785	1,690,624	78,452,687	17,406,028	8,372,152	25,778,180
1884	1,137,056	78,479,845	1,511,680	81,128,581	17,402,938	3,105,407	20,508,345
1885	1,468,775	67,689,250	1,442,067	70,600,092	17,404,698	4,495,759	21,900,457
1886	1,555,994	69,295,361	1,410,259	72,261,614	17,366,393	4,700,827	22,067,220

Year ending June 30—	Malt liquors consumed.			Total consumption of wines and liquors.	Total consumption per capita of population.			
	Malt liquors of domestic product.*	Imported malt liquors entered for consumption.	Total.		Dis-tilled spirits.	Wines.	Malt liquors.	All wines and liquors.
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Pr.galls*	*Galls.*	*Galls.*	*Galls.*
1840	23,162,571	148,272	23,310,843	71,244,817	2.52	0.29	1.36	4.17
1850	36,361,708	201,301	36,563,009	94,712,353	2.23	0.27	1.58	4.08
1860	100,225,879	1,120,790	101,346,699	202,374,461	2.86	0.35	3.22	6.43
1870	203,743,401	1,012,755	204,756,156	296,876,931	2.07	0.32	5.30	7.69
1871	239,838,137	1,299,990	241,138,127	321,031,851	1.62	0.40	6.09	8.11
1872	268,357,983	1,940,933	270,298,916	355,403,233	1.68	0.41	6.65	8.74
1873	298,519,675	2,177,587	300,697,262	387,581,432	1.63	0.45	7.27	9.29
1874	297,519,981	2,001,084	299,521,065	384,529,869	1.51	0.48	6.99	8.98
1875	292,961,047	1,992,110	294,953,157	381,065,045	1.50	0.45	6.71	8.66
1876	306,852,467	1,483,920	308,336,387	387,982,085	1.32	0.45	6.83	8.60
1877	303,854,988	1,072,679	304,926,667	386,723,115	1.29	0.47	6.58	8.34
1878	317,135,597	832,755	317,969,352	392,165,242	1.09	0.47	6.68	8.24
1879	343,724,971	880,514	344,605,485	423,261,090	1.11	0.50	7.05	8.66
1880	413,208,885	1,011,280	414,220,165	506,076,400	1.26	0.56	8.26	10.08
1881	442,947,664	1,164,505	444,112,169	538,882,175	1.37	0.47	8.63	10.47
1882	524,843,379	1,536,601	526,379,980	625,490,883	1.39	0.48	9.97	11.84
1883	549,616,338	1,881,002	551,497,340	655,728,207	1.45	0.48	10.18	12.11
1884	588,005,609	2,010,908	590,016,517	691,653,443	1.46	0.37	10.62	12.45
1885	594,063,095	2,068,771	596,131,866	688,632,415	1.24	0.38	10.44	12.06
1886	640,746,288	2,221,432	642,967,720	737,296,554	1.24	0.38	11.18	12.62

* Product less exports. † Included with "All other."

NOTES.—(1) The data as to product of domestic liquors and wines for 1840, 1850, and 1860 were derived from the Census. (2) The consumption of imported liquors and wines for 1840, 1850, and 1860 is represented by the net imports. (3) The production of domestic wines, from 1870 to 1885, has been estimated by the Department of Agriculture, by Mr. Charles McK. Leoser, president of Wine and Spirit Traders' Society, New York, and other well-informed persons, and the amount stated as consumed represents the production minus the exports. (4) The consumption of domestic spirituous and malt liquors, from 1870 to 1886, was obtained from the reports of the Commissioner of Internal Revenue. (5) In computing the quantity of sparkling and still wines and vermuth in bottles, five so-called quart bottles are reckoned as equivalent to the gallon. (6) The consumption of distilled spirits as a beverage is estimated to be about 90 per cent. of the product consumed for all purposes.

This table shows admirably the rapid increase, especially in the last ten years, of the consumption of malt liquors, and the relative decrease in the consumption of the stronger alcoholic beverages. Thus it will be seen that in 1840 the amount of malt liquor consumed per capita was a little over one-half the amount of distilled liquor consumed; while in 1886 it was *nine times as much.* The amount of distilled liquor consumed per capita has diminished during the twenty-six years to one-half, while the amount of malt liquor consumed has increased very nearly seven times; or, in other words, the malt liquors have been driving out the distilled at the rate of about .05 gallons per capita each year, and supplanting it at the rate of about .38 gallons per capita.

The average quantity consumed annually for the last three years was 609,705,367 gallons, of which 2,100,370 gallons were imported. Taking this as a basis, Mr. F. N. Barrett, in the publication above mentioned, estimates the amount expended for beer per annum at $304,852,683, placing the cost to the consumer at 50 cents per gallon. The cost to the consumer of the total quantity of liquors per annum he places at $700,000,000.

It is hardly necessary, after the above showing, to dwell upon the importance of this article of daily consumption, or the necessity of a thorough acquaintance with its manufacture, composition, and the nature and extent of its adulterations. There is no beverage that compares with it in the amount consumed by the people except water, and possibly milk. But little supervision has been exercised over its manufacture and sale, except the rigorous enforcement by the Government of its demands for a share in the profits of its manufacture.

THE PROCESS OF BREWING.

Brewing, or the art of preparing an alcoholic drink from starchy grains by fermentation, is of very ancient origin. It was practiced by the Egyptians, and the Greeks and Romans learned the art from them. Herodotus speaks of the Egyptians making wine from corn, and it was undoubtedly practiced by the Greeks in the fifth century before Christ, as the use of malt beverages is mentioned in the writings of Æschylus and Sophocles, poets of that period. It is also mentioned by Xenophon, 400 B. C. The Romans are also supposed to have derived a knowledge of the art from the Egyptians, and Pliny and Tacitus both speak of its use among the Gauls and Germans of Spain and France.

It is supposed that the art was introduced into Britain by the Romans and acquired from the natives by the Saxons. According to Verstigan, "this excellent and healthsome liquor, beere, anciently called ale, as of the Danes it yet is, was of the Germans invented and brought into use." Ale-houses are mentioned in the laws of Ina, king of Wessex, A. D. 680. Ale-booths were regulated by law A. D. 728.

The art of producing an alcoholic drink from starchy seeds seems to have been nearly as extensively known and practiced among the various nations of the earth as the less complex operation of preparing a fermented liquor from the juice of fruits and plants containing sugar. Thus the Kaffre races of South Africa are said to have prepared for many years a malt liquor from the seeds of the millet (*Sorghum vulgare*), going through all the processes of germinating the seed, extracting the malt, and fermenting the wort. In the north

of Africa another seed is used. The Chinese prepared the drink called sam-shee from rice.

The process of brewing consists of two distinct operations: the malting and the brewing proper. In fact the two operations are frequently separated, many small breweries buying their malt ready prepared. When kept dry it retains its qualities for an indefinite period and is handled as an article of commerce.

MALTING.

The object of this operation is the germination of the grain, and the consequent formation of the ferment diastase, which shall subsequently, under the proper conditions, perform its specific function of converting the starchy portions of the grain into saccharine or fermentable matter. Barley is the grain used almost exclusively for this purpose, its advantages having been recognized even by the Egyptians; they seem to be principally of a physical character, consisting of the firmness of the kernel, and the hard husk, which freely allows the entrance of water, but prevents the passage of starch or insoluble matter.

The operations through which the grain is successively passed are called, technically, steeping, crushing, flooring, and kiln-drying. In the first it is spread out in large vats, covered with water, and allowed to steep several days. When it has become softened, the water is run off and the swollen grain is subjected to a slight degree of heat, which causes it to germinate. This is the second operation. The operation of flooring has for its end the regulation of the germination of the grain, and the time when it has progressed sufficiently is judged by the length which has been attained by the acrospire or plumule. This is variously given as from two-thirds to seven-eighths the length of the grain. The sprouted grain is now spread out in the malt kilns and heat applied, while a current of air circulates about it. After the moisture is driven off, which is done at a low temperature, about 90° F., the heat is raised, and finished at from 125° to 180° F., according to the grade of malt required, the difference between pale, amber, and brown malt being due simply to the temperature at which they are kiln-dried. This last operation serves not only to drive off the moisture, but also stops germination by destroying the vitality of the germ, and fits it for keeping. It also probably develops the flavor by the formation of a minute quantity of empyreumatic oil in the husk.

The rootlets and germs are removed in this process by the turning and stirring of the grain. The water which is used in the process of steeping the grain is an important factor in the production of good malt, and the preference of brewers for hard lime waters for this purpose has been shown by recent experiment to be rational, for it is found that when barley is steeped with distilled water, a very putrescible liquor is obtained charged with albuminous matter, while if a hard water is used these matters remain in an insoluble condition in the grain.

BREWING.

Brewing proper includes a number of distinct operations, such as grinding and mashing the malt, boiling and cooling the wort or infusion, fermenting it, and clearing and racking the beer. In the process of mashing takes place the conversion of the starch into fermentable sugar, mainly maltose, by the action of the diastase. Two

methods are used for extracting the soluble matter from the malt, called *infusion* and *decoction*, respectively; the former is the method most in use in England, the latter in Germany and France. The wort prepared by infusion contains less dextrin and more albuminoid matter than that prepared by decoction; the beers from the former are stronger in alcohol, but not so good in keeping qualities.

A good wort should give no blue color with iodine, showing the complete conversion of all the starch, and should contain a large percentage of maltose, which should constitute about 70 per cent. of the extract.

After the mashing process comes the *boiling* of the wort, which is begun as soon as it is drawn off from the exhausted malt and continued for one to two hours. This prevents the formation of acid, and serves to extract the hops, which are added at this stage of the process. The boiling of the wort with hops serves not only to impart to it the desired hop flavor, but also to partially clarify it by precipitating some albuminous matter by means of the tannin in the hops, and to enhance its keeping qualities. To this end larger quantities of hops are used for beers intended for exportation or long keeping.

The wort is now ready to be submitted to the most important operation of all—fermentation—which calls for very careful supervision on the part of the brewer.

FERMENTATION.

After the wort has been boiled with hops it is cooled as rapidly as possible, to prevent the formation of acid, usually effected by means of artificial refrigerating apparatus; it is then ready for the addition of the yeast.

There are two distinct methods of fermentation in use, called by the Germans *Ober- und Untergährung*, and by the French *fermentation haute* (top fermentation) and *basse* (bottom fermentation). The former is carried on at a comparatively high temperature, the action is rapid, and the yeast with the impurities is carried to the surface of the liquid; in the latter method the temperature is kept low, the fermentation goes on slowly, and the yeast and impurities sink to the bottom. The second method is often called the Bavarian method, as it seems to have originated there, and is used exclusively in that country. It is generally preferred in Germany and France, while in England and this country the upward clearing method appears to be more in vogue.

The nature of the fermentation depends greatly upon the character of the yeast used, for Pasteur's experiments have shown that yeast from upward-fermented beer tends to produce the upward fermentation, while yeast from bottom-fermented beer produces the bottom fermentation. The purity of the yeast used is of the very first importance in the production of good beer.

CLARIFYING, STORING, AND PRESERVING.

The treatment of malt liquor after the process of fermentation is complete is very diverse, according to the kind of liquors it is intended to produce, the length of time it is to be kept, etc. The problem of clarifying and preserving the beer is very simple of solution if it has been properly and carefully brewed, for then it is easily cleared and keeps well; but where the reverse is the case it is necessary to make use of various clarifying and preserving agents, and

here comes in the delicate question of the proper agents to use, which will perform this duty and still introduce no objectionable constituents into the drink.

The discussion of this question comes properly under the head of adulterations, and will be considered later on. As clarifying agents may be mentioned gelatine, tannin, Iceland moss, and flaxseed, and as mineral coagulating agents phosphate of lime and alum.

Formerly beer was stored in casks or vats in cool cellars for a long period. to allow it to age or ripen, especially in Germany, whence came the name of "lager" beer; but the aim of the brewer at the present day is to produce an article fit for the market in as short a time as possible and thus turn his capital often and keep step with the rapid pace of modern business industry, so that the name of lager beer is rather a misnomer.

COMPOSITION OF MALT LIQUORS.

The composition of malt liquor varies greatly according to the materials used, the method of brewing, the season, and the use for which it is intended.

Malt liquors, properly so called, should be made only of malted barley, hops, yeast, and water, but the use of other materials as substitutes for the first three ingredients has extended so greatly in countries where their use is not prohibited that it is difficult to define what a beer really is.

Modern beer has been defined as a "fermented saccharine infusion to which some wholesome bitter has been added."

Its chemical composition is very complex, the principal constituents being alcohol, various sugars and carbohydrates, nitrogenous matter, carbonic, acetic, succinic, lactic, malic, and tannic acids, bitter and resinous extractive matter from the hops, glycerine, and various mineral constituents, consisting mainly of phosphates of the alkalies and alkali earths.

VARIETIES.

The names given to different kinds of malt liquors relate to various attributes, as the country where they were produced, as English, German, Bavarian beer, etc., or to the peculiarities in the method of brewing, etc. Thus, *porter* is simply a beer of high percentage of alcohol, and made from malt dried at a somewhat high temperature, which gives its dark color; *ale* is a pale beer, likewise of high attenuation and made of pale malt, with more hop extract than porter. *Stout* has less alcohol and more extract and still less hops than porter. These terms are used chiefly with reference to English malt liquors. The terms used for German beers, such as *Erlanger, Münchener*, etc., are for the most part names of places and are applied to beers made in imitation of the beers originally brewed in those cities. *Export* beer is beer that is specially prepared with a view to long-keeping qualities.

COMPOSITION OF AMERICAN BEER.

But very little work has been done on American beers; they seem to have shared with other dietary articles the general indifference of the American public to the composition of their food and drink.

A very extensive series of analyses was made in the State of New York in 1885, under the authority of the State Board of Health, by

Dr. F. E. Englehardt, and outside of this I have been able to find very few published analyses of American beers.

Dr. Englehardt's analyses were made upon a very large number of samples, 476 in all, which were collected from all over the State, and were intended to furnish a good average representation of the beer retailed in the State. The samples included various kinds of malt liquor, porters, ales, and a weak beer sold under the name of weiss beer. Unfortunately no arrangement of the analyses was made with a view to showing the composition of various kinds, as the examination was made principally with reference to the adulteration, so all varieties are tabulated together. The following averages I have had compiled from his table by the Statistical Division of this Department, only excepting a few samples which he has indicated as being imported:

Average composition of American malt liquors, as shown by analyses made for New York State Board of Health by F. E. Englehardt, Ph. D.

Kind.	Specific gravity.	Alcohol, by weight.	Extract.	Ash.	Phosphoric acid.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Lager, 172 samples	1.016	3.754	5.864	.259	.0964
Ale, 199 samples	1.013	4.622	5.423	.307	.0832
Porter, 70 samples	1.015	4.462	6.003	.345	.0942
Weiss, 28 samples	1.006	1.732	2.356	.189	.0491

The maximum and minimum content of alcohol, extract, and ash in the same samples is as follows:

Kind.	Maximum.			Minimum.		
	Alcohol, by weight.	Extract.	Ash.	Alcohol, by weight.	Extract.	Ash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Lager	7.061	9.647	.412	.677	3.655	.172
Ale	8.994	9.501	.552	2.410	2.703	.197
Porter	6.695	11.783	.557	1.671	2.843	.170
Weiss	3.179	4.143	.468	.755	1.277	.069

These analyses show great lack of uniformity of composition in the different varieties of malt liquor, but it should be remembered that the samples were collected with a view to ascertaining the extent of adulteration, and many samples were found to be sophisticated in one way or another. Especially in the case of the content of ash the average of these samples does not give the average composition of American beers, for many of these ashes were found to consist principally of salt.

ANALYSES OF BEERS BY THE UNITED STATES DEPARTMENT OF AGRICULTURE.

The analyses made by this Department comprise 32 samples, this being about all the different brands and varieties of beers of domestic manufacture obtainable in Washington. The investigation was made principally with a view to ascertain the extent and nature of their adulteration, if any, and especially the use of antiseptic and preserv-

ative agents. As a basis for determining adulteration, however, it is necessary to know the normal or average composition, so a fairly complete analysis of all samples examined has been made. The intention of the investigation was not so much to make a very extensive series of analyses as to establish definite methods of analysis for the guidance of analysts of State boards of health or similar bodies, whose province it is more especially to investigate the extent of adulteration prevailing in their States by the examination of large numbers of samples.

SAMPLES.

The malt liquors used as samples were all purchased in Washington, D. C., and included the various popular brands made in Milwaukee, Cincinnati, Philadelphia, New York, etc., which are sold all over the country, as well as the product of the few local brewers. Some were obtained from wholesale dealers, but the majority were purchased in retail saloons and groceries, without statement of the purpose for which they were intended. All the draught beers were obtained in this way.

A few English and German beers and ales were analyzed for comparison.

Analyses of malt liquors by United States Department of Agriculture.

Designation.	Manufactured in—	Serial number.	Number of analysis.	Specific gravity.	Alcohol, by weight.	Alcohol, by volume.	Extract.	Original gravity.	Ash.	Reducing sugar as maltose.	Dextrin.	Albuminoids.	Free acids as lactic.	Phosphoric acid.	Carbonic acid.	Remarks.
					Pr. ct.	*Pr. ct.*	*Pr. ct.*		*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	
Lager beer, bottled	Milwaukee, Wis	4800	1	1.0100	4.28	5.39	4.18	1.0505	.196	1.10	1.57	.511	.057	.065	.411	
Export beer, bottled	...do	4801	2	1.0140	4.12	5.55	5.40	1.0537	.309	1.06	2.63	.400	.057	.056	.300	Salicylated.
Lager beer, bottled	Alexandria, Va	4802	3	1.0171	4.55	5.71	5.71	1.0607	.355	2.04	2.21	.681	.074	.091	.459	Salicylated.
Do	Washington, D. C	4803	4	1.0143	4.18	5.24	5.05	1.0533	.388	1.25	0.98	.669	.059	.056	.415	
Do	Cincinnati, Ohio	4804	5	1.0100	5.53	6.94	4.55	1.0628	.240	0.94	2.25	.513	.073	.082	.328	
Export beer, bottled	Saint Louis, Mo	4805	6	1.0178	4.40	5.47	6.15	1.0590	.312	2.14	2.54	.463	.067	.074	.471	Salicylated.
Lager beer, bottled	Philadelphia, Pa	4806	7	1.0147	4.29	5.39	5.22	1.0549	.241	1.46	2.30	.598	.078	.071	.717	Salicylated and soured.
Do	...do	4807	8	1.0147	4.35	5.47	5.09	1.0549	.272	1.37	1.80	.738	.080	.104	.219	
"Budweiss" beer, bottled	...do	4808	9	1.0181	4.52	5.63	5.94	1.0609	.241	2.14	2.57	.531	.086	.078	.324	
Lager beer, draught	Buffalo, N. Y	4810	10	1.0241	3.84	4.78	7.05	1.0601	.222	2.81	3.09	.519	.035	.069	.....	
Do	Philadelphia, Pa	4811	11	1.0132	4.36	5.47	4.63	1.0539	.265	1.17	1.82	.636	.046	.095	.....	Substitutes for hops used.
Do	Washington, D. C	4812	12	1.0146	4.29	5.39	5.18	1.0545	.236	1.22	2.21	.669	.044	.086	.....	
Do	Cincinnati, Ohio	4813	13	1.0169	4.63	5.78	5.86	1.0607	.235	2.37	2.29	.456	.074	.085	.....	
Do	Alexandria, Va	4814	14	1.0137	4.71	5.86	4.91	1.0585	.263	1.10	2.40	.619	.008	.089	.....	Bicarbonate of soda used.
Do	Washington, D. C	4815	15	1.0140	4.30	5.39	4.83	1.0538	.262	1.49	1.45	.681	.071	.087	.....	Sulphite used.
Do	...do	4816	16	1.0181	3.86	4.85	5.62	....	.312	1.52	2.59	.619	.000	.083	.....	Bicarbonate of soda added.
Pale lager beer, bottled	Saint Louis, Mo	4817	17	1.0178	4.28	5.39	4.64	1.0527	.183	2.17	2.75	.463	.067	.064	.629	Salicylated.
"Erlanger" beer, bottled	...do	4818	18	1.0203	4.68	5.86	6.82	1.0650	.212	2.51	2.58	.675	.046	.093	.344	
Ale, bottled	Philadelphia, Pa	4819	19	1.0059	6.24	7.74	3.46	1.0647	.401	0.59	0.99	.531	.232	.085	.....	
Bass pale ale, bottled	England	4820	20	1.0095	5.66	7.09	4.42	1.0633	.309	0.49	2.20	.500	.117	.056	.503	
English porter, bottled	...do	4821	21	1.0147	6.13	7.66	5.90	1.0728	.371	0.57	2.76	.763	.151	.049	.397	
Lager beer, bottled	Boston, Mass	4822	22	1.0077	5.30	6.63	3.94	1.0587	.328	1.06	1.63	.556	.107	.065	.....	
"Kaiser" beer, bottled	Bremen	4823	23	1.0036	5.38	6.71	3.05	1.0543	.162	0.69	1.36	.263	.089	.045	.....	Salicylated.
"Verzandt" beer, bottled	Bavaria	4824	24	1.0197	3.86	4.85	6.24	1.0553	.190	1.71	3.32	.419	.085	.073	.....	
Export beer, bottled	Milwaukee, Wis	4825	25	1.0150	4.59	5.71	5.38	1.0581	.194	1.87	2.46	.425	.071	.059	.....	Salicylated.
Ale, draught	Philadelphia, Pa	4826	26	1.0171	5.25	6.55	6.02	1.0669	.331	1.49	2.80	.569	.094	.057	.....	
Ale, bottled	Reading, Pa	4827	27	1.0125	6.92	8.63	5.55	1.0781	.472	0.93	1.99	.731	.382	.077	.441	
Porter, bottled	...do	4828	28	1.0269	4.89	6.10	8.19	1.0736	.412	2.67	2.88	.763	.166	.100	.592	
"Select" beer, bottled	Milwaukee, Wis	4842	29	1.0183	4.22	5.32	5.88	1.0570	.193	1.88	2.82	.419	.061	.059	.....	
Export beer, bottled	...do	4843	30	1.0183	4.22	5.32	5.84	1.0567	.223	1.75	3.12	.413	.053	.058	.242	
"Bohemian" beer, bottled	...do	4844	31	1.0183	4.16	5.24	5.88	1.0563	.224	1.82	3.04	.406	.071	.057	.....	
"Bavarian" beer, bottled	...do	4845	32	1.0187	5.06	6.32	6.26	1.0660	.346	1.75	2.87	.556	.074	.077	.265	
Average (28 samples)*	....	.....	.....	1.0161	4.63	5.79	5.53	1.0597	.279	1.65	2.33	.563	.082	.077	.398	

* In the averages the five samples of foreign beer were omitted.

DETECTION OF ADULTERATION.

Probably there is no one article of daily consumption that has been so often subject to suspicion of adulteration or sophistication as beer. Its complex composition and peculiar nature have deceived people into making all sorts of charges against its purity, but experience has failed to establish the truth of by far the greater majority of these charges, and the facts of many published analyses show that it is as free from adulteration as most other articles of consumption, and more so than some. Here comes in the question, so difficult to answer in this country, of what constitutes adulteration or sophistication of an article of food. The definition of what shall constitute a pure malt liquor is hard to settle. Even in Europe, where a much stricter supervision is kept over food-stuffs than here, the definition varies widely. In Bavaria, where more beer per capita is consumed than in any other country, the laws limit the materials from which it is made to barley, malt, hops, yeast, and water, while in England the comprehensive definition has been given to beer as being "a fermented saccharine infusion to which a wholesome bitter has been added."

SUBSTITUTES FOR MALT.

A great deal has been said, pro and con, on the subject of the propriety of the use of other matter than malted barley as a source of saccharine material for brewing purposes. There may be said to be three ways of substituting saccharine material. First, other grain may be used for malting; second, unmalted starchy matter, that is, whole grain, may be added to the malt before it is mashed, the latter being diluted, as it were, for the diastase in the malt has converting power sufficient for considerably more starch than is contained in itself; third, the saccharine matter may be supplied already converted, as in commercial starch sugar, or glucose, cane sugar, inverted cane sugar, etc. Of these different substitutes the third class is probably the more objectionable, as beer brewed from such saccharine matter is lacking in various constituents derived from the grain, which are important additions to its nutritive power, namely, the phosphatic salts and the nitrogenous bodies.

In much the same way would bread made from starch alone be lacking in nutritive value.

SUBSTITUTES FOR HOPS.

The nature of the bitters used in beer has long been the target towards which public suspicion is directed, and nearly every substance known possessing a bitter taste has been enumerated among the adulterations of beer, from poisonous alkaloids, such as strychnine and picrotoxine, to harmless or quasi-harmless bitter roots and woods, such as quassia, gentian, etc. Complete and exhaustive schemes of analysis have been compiled, such as Dragendorff's, Ender's, etc., for the detection and isolation of such foreign bitters. Either these methods of investigation are faulty or difficult of manipulation, or the use of foreign bitters is very much less prevalent than is generally supposed; for the cases where such bitters have been detected and isolated are very scarce in chemical literature. In fact, Elsner, a German authority on food adulterations, goes so far as to say that there has never been a case where the existence of a foreign bitter in

a malt liquor has been proven with certainty. This is going too far, of course, for picrotoxine and picric acid have undoubtedly been found in beers, and probably more cases of such adulteration would occasionally have been discovered were it not for the difficulty of the analysis and the small quantity of matter required for imparting a bitter taste. But there is probably much less of this hop substitution than the space given it in works on the subject would indicate. Hops not only give the bitterness to beer, but also impart to it its peculiar aroma and enhance its keeping qualities, and, unless it were at a time when they were very dear, it would hardly pay the brewer to sacrifice the good flavor and keeping qualities of his beer in order to save a few cents a pound in his bitters.

All the samples analyzed were found to be free from foreign bitters, with one exception, No. 4811, which contained a bitter other than hops, though not in sufficient quantity to admit of its separation and identification. All the samples except Nos. 4801, 4811, and 4815 gave a plainly perceptible odor of hops in the distillate.

PRESERVING AGENTS.

We come now to what I consider the most important sophistication of beer at the present day and the most reprehensible and most deserving of repressive legislation. The use of artificial preserving agents not only introduces foreign matters into the beer which are more or less injurious, according to the nature of the material used, but also serves to cover up and hide the results of unskillful brewing or unfit materials; giving to the public for consumption a liquor that, if left to itself under natural conditions, would have become offensive to the senses and putrid with corruption long before it was offered for sale.

The only means of preservation allowed by the authorities in Germany and France is the process called, from the name of its author, "Pasteurization." This process is entirely rational and commendable, as it conduces to the preservation of the beer by destroying the germs of unhealthy ferments, not by simply paralyzing their activity as antiseptics do, and moreover it introduces no foreign constituents into the beer. Liquid carbonic acid is also coming into use in some of the larger Continental breweries.

Other preservative agents extensively employed at the present day are salicylic acid, bisulphite of lime, and boracic acid.

SALICYLIC ACID.

Salicylic acid ($C_7H_6O_3$) was first prepared by Piria and Ettling by oxidizing salicyl aldehyd, which had previously been obtained from various vegetable sources. It was afterwards obtained from oil of wintergreen, which is nearly pure methyl salicylate, a constituent also of many other essential oils. Its artificial production from phenol (carbolic acid) was discovered by Kolbe and Lautermann in 1860 but was not put into practical use until 1874, when Professor Kolbe succeeded in producing it at a moderate cost. It is now prepared almost exclusively in this way, the cheapness of the method having driven out of the market that which is prepared from oil of wintergreen.

In medicine, besides its use externally as an antiseptic, it is administered very extensively internally, its chief application being as a

remedy for acute rheumatic fever. Its physiological action is given as follows in the United States Dispensatory, fifteenth edition, page 101:

When salicylic acid is given to man in doses just sufficient to manifest its presence, symptoms closely resembling those of cinchonism result. These are fullness of the head, with roaring and buzzing in the ears. After larger doses, to these symptoms are added distress in the head or positive headache, disturbances of hearing and vision (deafness, amblyopia, partial blindness), and excessive sweating. According to Reiss (*Berlinger Klin. Wochenschrift*, 1875, p. 674) decided fall of temperature, without alteration of the pulse, also occurs; but this is denied by other observers. The actions upon the system of the acid and of its sodium salts (also ammonium salt, Martenson, *Petersb. Med. Zeitschrift*, 1875, p. 243) appear to be identical, and, as several cases of poisoning with one or other of these agents have occurred, we are able to trace the toxic manifestations. Along with an intensification of the symptoms already mentioned there are ptosis, deafness, strabismus, mydriasis, disturbance of respiration, excessive restlessness passing into delirium, slow laboring pulse, olive-green urine, and involuntary evacuations. In some cases the temperature has remained about normal, but in others has approached that of collapse. The respiration seems to be characteristic, it being both quickened and deepened, often sighing. Sweating is usually very free, and the urine early becomes albuminous. Various local evidences of vaso-motor weakness may supervene, such as rapidly-appearing bed-sores at points subjected to pressure, and transitory dark-colored maculæ on various parts of the body. In several cases death was probably produced by the acid, although there is scarcely one instance which is beyond doubt.* In certain cases the mental disturbance has been strangely prolonged, lasting for eight days. In some instances it is cheerful, in others melancholic in type. It is stated that upon drunkards the acid acts very unfavorably, violent delirium being an early symptom of its influence.

By the same authority the dose of salicylic acid to be employed in cases of acute rheumatism is given as one dram (3.9 grams) in twenty-four hours. It is excreted chiefly by the kidneys and may be detected in the urine very soon after its ingestion. Authorities in therapeutics warn practitioners of medicine against its administration to patients whose kidneys are known to be diseased, and of late years the opinion has been growing among physicians that it has a very irritating action upon these organs, many preferring the alkaline treatment of rheumatic fever on this account.

USE AS A PRESERVATIVE.

The "salicylic-acid question," as it is called, has received a great deal of attention for several years in Europe, and much has been written, pro and con, on the question of the propriety of its use as a preserving agent in articles of food and drink. In France its use as a preservative in any form of food or drink was forbidden by ministerial decree on the 7th of February, 1881. This decree was based upon a decision of the consulting committee of hygiene that its constant use was dangerous to health.

In Germany its use is prohibited, except in beers intended for export to other countries where its use is allowed.

Its prohibition in France called forth a great deal of opposition, and experiments were made and published which were intended to show that its constant use in small doses exerted no injurious influence upon the system. Kolbe himself made experiments upon himself and his assistants by taking doses of .5 to 1.0 gram daily for

* In the case recorded in the Virginia Medical Monthly, June, 1877, forty-eight grains of the acid were taken in four hours. The symptoms were violent vomiting, headache, total unconsciousness, with stertorous breathing. Death occurred forty hours after the first dose.

several days, and found no appreciable ill effects to follow its use.* Whether such experiments suffice to prove its harmlessness when used for many years and without regard to age, sex, or personal idiosyncrasy is still an open question. A most interesting and exhaustive discussion of the reasons for and against its use can be found in the report of the fourth meeting of the "Independent Union of the Bavarian Representatives of Applied Chemistry, at Nürnberg, 7th and 8th August, 1885,"† when this body refused, with but one dissenting voice, to grant its sanction to the proposed use of salicylic acid in beer in the quantity of .05 grams to the liter. Certainly no one would deny the advisability of at least restricting the amount to be used of so powerful an agent. In an article of daily consumption, and in consideration of the prevalence of kidney disease‡ at the present day, it is a matter worthy of grave consideration whether it would not be more prudent to forbid its use altogether. At all events, beer in which it is used should be sold under its proper designation as "salicylated beer." It would certainly be of interest to the physician who prescribes beer as a tonic to a weak convalescent invalid to know if he were giving at the same time not inconsiderable doses of a strong therapeutic agent, expressly contra-indicated, perhaps, in the case he has on hand.

SALICYLIC ACID IN SAMPLES EXAMINED BY THIS DIVISION.

Out of thirty-two samples analyzed by this division I found seven to contain salicylic acid in sufficient quantities to admit of qualitative proof, or nearly one-fourth of the entire number analyzed. The serial numbers of these beers corresponding to those in the large table on page 191 are as follows: 4801–3–5–6–17–23–25. These were all bottled beers, one being an imported (Kaiser) beer. None was found in any of the draught beers. Of the nineteen samples of American bottled beers, six contained salicylic acid, or nearly one-third. These included the product of some of the largest breweries in the country, beers that are used to a very large extent all over the United States. Whether the acid is added in the breweries where the beer is made, or whether it is used by the local bottlers, I am unable to decide. In one case I found it in the beer sold here under the brand of a large Western brewery, and sent direct to the same brewery for another sample, which gave no test for the acid. Unfortunately I can not be sure in this case that the firm in question did not know the purpose for which the sample was intended.

SULPHITES.

The use of sulphurous acid as a preservative agent in beer and wine, either in the form of soluble sulphites, liquid sulphite of lime, or sulphur fumes, is not at all recent. It is one of the oldest preservatives known. Together with other chemical preservatives its use is forbidden in France, and the German authorities include it with borax as an agent whose physiological effect is still too little known to allow of its indiscriminate use. It is also sometimes introduced into beers by the hops, which are very generally preserved by means of sulphur fumes. The Bavarian authorities allow its use in sulphur-

*Jour. prak. Chem. 13, 106. Reference may be made to similar experiments, as follows: J. A. Barral, Jour. de l'Agriculture, 1882. 69. M. Blas, Bull. de l'Acad. Royale de Méd. de Belgique. Bd. 12, No. 9.

†Published by Drs. A. Hilger and R. Kayser, Berlin, 1886.

‡The most common form is popularly known as "Bright's disease."

ing barrels and hops. Of course the quantities brought into the beer in this way are very small.

Of the samples examined by the Department, Nos. 4804–6–10–13 and 14 gave slight tests for the presence of sulphurous acid, but only one (No. 4815) gave sufficient evidence to justify the assertion that a sulphite had been added to it. I have not been able to find any recorded instance of sulphurous acid being found in American beers.

BORAX.

This agent, although used very extensively in preserving meats, vegetables, and canned goods, does not seem to have been applied to malt liquors to any great extent, although it has been found in wines. Its use is prohibited in France and Germany. None of the samples examined gave any test for borax.

In conclusion of the work on preservatives, it may be noted that it was done during the cold weather of January, February, and March. It is quite probable that during warm weather the use of preservative agents is still more general than shown by the analyses.

MINERAL ADDITIONS.

The presence of lead, copper, or zinc, sometimes observed in malt liquors, is due usually to the use of brass faucets or lead pipes by the retailer in drawing off the liquor or in filling bottles. The amount of these metals taken up by acid liquors in this way is quite small usually, but may be considerable if they are long left in contact with the metallic surface. Thus the first glass drawn from a faucet in the morning is apt to contain considerable copper and zinc in solution. In Paris the apparatus used for drawing beer is subject to supervision, and a frequent cleansing and proper kind of material is insisted on. The Brooklyn Department of Health issued an order in 1886 prohibiting the use of unprotected brass faucets in drawing beer, but its enforcement has not been insisted on.* Analyses made for the board by Otto Grothe of ales drawn through pumps showed small quantities of copper, zinc, and lead in every case.†

Alum is sometimes used as a clarifying agent in the brewing of beer.

BICARBONATE OF SODA.

This salt is added to beer for the purpose either of correcting an undue acidity of the beer, resulting from improper brewing, or of imparting to it an increased "head" or content of carbonic acid gas, or for both purposes. The salt is decomposed by the free acid of the beer and the gas liberated, lactate and acetate of soda being left dissolved in the beer. This seems to be purely an American practice; at least I have failed to find any mention of it in European authorities. Some of them mention the use of marble dust or magnesia for the correction of acidity, but very little consideration is given to the subject. In this country, however, it seems to be very wide-spread.

It may be necessary to explain to a non-scientific reader that the bicarbonate does not remain in the beer *as bicarbonate*, unless there is an amount added in excess of the quantity of free acid present in the beer. This free acid (mostly acetic in soured beers, but due chiefly to acid phosphates in normal beers) combines with the bicar-

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* Annual Report Dept. Health, City of Brooklyn, 1886, p. 87; and 1887, p. 63.
† Ibid.

bonate, setting free carbonic acid, and forming acetate of soda and basic phosphate, which remain in solution. The reaction is very similar to that which takes place in using baking powders for cooking purposes, except that in the latter case tartrate of soda and potash (Rochelle salts) is left instead of acetate and phosphate of soda. Where bitartrate of potash is added to the beer along with the soda the reaction is precisely the same. In these days of the almost universal consumption of baking powders there is doubtless enough alkaline salts thrown into a man's stomach with his food without pumping them in with his drinks as well. At all events there can be but little question of the propriety of prohibiting the use of bicarbonate of soda in beer. It is entirely unnecessary and foreign to the production or preservation of pure beer. Moreover, its use serves to cover up and hide the effects of poor brewing and improper storing or refrigerating, and should be prohibited from this cause alone if there were no other.

Of the samples examined here, Nos. 4814 and 4816 were found to have suffered an addition of bicarbonate of soda.

SALT.

A variable quantity of chloride of sodium is a normal constituent of all beers, being derived principally from the water used in the brewing. Even a slight further addition of salt might be deemed admissible to properly "season" the beer to the taste, just as breadstuffs are treated. Many brewers, however, are in the habit of adding a large quantity, either for the purpose of covering up some objectionable taste or of increasing the thirst of the consumer. The English Government places the limit of chloride of soda which might come from the normal constituents at 50 grains to the gallon, or about .086 per cent., and treats any excess of that amount as evidence of an improper addition. This standard is undoubtedly a very generous one. Dr. Englehardt found quite a large number of the samples examined by him to overstep the limit of 50 grains to the gallon, one sample containing as high as .338 per cent. Of the samples examined here none were beyond it.

CLOUDY BEER.

Cloudiness in beer is sometimes due to the separating out of albuminous matter from changes in temperature, but usually to the presence of yeast, the fermentation not having been complete. This condition of things is best detected by means of the microscope, which shows the presence of quantities of yeast cells, and, in case other fermentations have set in, of their characteristic bacteria. "Yeast-cloudy" (*hefetrübes*) beer is considered unhealthy in Germany, and it is considered one of the qualifications of a good beer that it shall be absolutely bright and clear. An extensive investigation of the unhealthfulness of yeast-cloudy beer, has been lately made by Dr. N. P. Simonowsky* in Pettenkofer's laboratory, who found that such beer had a disturbing effect in both natural and artificial digestion, producing in persons using it obstinate catarrh of the stomach, which persisted for some time. Both Simonowsky and Pettenkofer conclude that the sale of yeast-cloudy beer should be prohibited.

*Zeit. für das gesammte Brauwesen?, 9 Jahrg. 1886, Nos. 7, 8, 9; abstract Bied. Cent., 1887, p. 70.

The Bavarian chemists, at their last meeting at Würzburg, in August, 1886, adopted the following resolution in relation to yeast-cloudy beer:

Beers which are incompletely fermented for use must be entirely free from yeast; that is, must not contain yeast in a cloudy suspension.

WINES.

The statistics in regard to the consumption and production of wines can be observed by referring to the table given under malt liquors (page 186), where it will be seen that in the year 1886, 22,067,220 gallons were consumed, of which 17,366,393 gallons were produced in this country. The consumption per capita has not increased very greatly during the forty-six years since 1840, but the total amount consumed has increased very greatly, it being less than 5,000,000 gallons in 1840. It will be noticed also that the amount produced in this country in proportion to the amount imported has increased to a remarkable degree. In 1840 there was about thirty-eight times as much wine imported as was produced in this country; in 1886 the amount of domestic wine consumed was nearly four times as great as the amount of wine imported. This does not fully represent the production, however, for it does not include the exports, which have increased very greatly of late years, as I am reliably informed, although I have no accurate data upon this point. The largely increased domestic production is principally due to the development of the industry in California.

The following table shows the relative rank of this country among the wine-producing countries of the world; it is taken from the same source as the preceding statistics:

WINE PRODUCTION OF THE WORLD.

Average production of wine in the principal wine-growing countries of the world.

[Estimate by M. Tisserand in 1884, taken from "Journal of the Statistical Society," London, 1885.]

Countries.	Production.	Countries.	Production.
	Imperial gallons.		*Imperial gallons.*
France	765,175,972	Greece	28,600,000
Algeria	722,000,000	United States	18,000,000
Italy	605,000,000	Turkey	22,000,000
Spain	484,000,000	Cape of Good Hope	15,400,000
Austria-Hungary	187,000,000	Roumania	15,400,000
Portugal	88,000,000	Servia	11,000,000
Germany	81,290,000	Australia	1,933,800
Russia	77,000,000		
Cyprus	35,200,000	Total	2,485,599,772
Switzerland	28,600,000		

PREPARATION OF WINE.

The growing of grapes for wine and the proper treatment of the juice for its conversion into wine have formed the subject of numerous treatises, that branch of technology having received a great deal of attention and study in countries where it is carried on. Only a short sketch of the leading features of the process can be given here, necessary to a proper understanding of the product itself.

Wine is properly the pure fermented juice of grapes; its composition is very variable, and the differences in the varieties of grapes used admit of almost endless modifications of the product obtained from them. Moreover, many other conditions affect more or less the composition of wine, as the nature of the soil, the climate, the method of cultivation pursued, the weather during the particular season when the grapes were ripened, etc. Thus the same variety of grapes, when grown under different conditions of soil, climate, etc., produces different wines, and even in the same country the same variety of grape produces wines varying considerably in different seasons.

The most important constituent in the grape is its sugar, from which the alcohol is formed, so as a general rule the grapes are allowed to become fully ripened before they are removed from the vine. The first step is the production of the *must*. To this end the grapes are first bruised and crushed, either by the aid of machinery or by the more primitive but very effective method of trampling them by the feet of men. In some cases, and for very fine wine, the woody stems are removed from the crushed grapes (*dérâpage*). In other cases, especially in white wines, they are left, their contents of tannin making them a desirable addition to the grapes. To obtain the juice the grapes are subjected to pressure. The amount obtained varies with the means employed, the kind of grape, etc., but may be stated at about 60 to 70 per cent. of the weight of the grapes. For red wines the juice is allowed to stand in contact with the skins a variable length of time until it has acquired from them the desired depth of color, and in this case the fermentation commences before the juice is expressed. All musts contain pretty much the same proximate principles, their differences being due solely to the relative proportions of the different constituents. Briefly stated, these constituents are as follows:

(1) Saccharine matter (chiefly dextrose), which may constitute as high as 25 to 30 per cent. of the must.

(2) Albuminoid matter.

(3) Gummy matter, pectin, etc.

(4) Extractive matter, illy-defined substances, comprising the coloring matters, if any, the flavoring matters, etc.

(5) Organic acids and their salts, comprising malic acid (especially in bad seasons), a slight trace of tannic acid derived either from the stems or skins, and tartrates of potassium and calcium.

(6) Mineral matters: Phosphoric, sulphuric, hydrochloric, and silicic acids combined with potassium, sodium, iron, and magnesium.

Water, 70 to 90 per cent.

The must is fermented in suitable vats of wood or stone, according to the usage of the country; the fermentation is produced spontaneously, that is, by germs accidentally introduced into it from the air or on the surface of the grapes themselves. If the fermentation does not take place promptly it is started up by introducing into it a supply of yeast-cells from some must which is already in a state of fermentation. Sometimes a small quantity of must is fermented in anticipation of the vintage season as a "sponge," its fermentation being first induced by a small quantity of well-washed beer yeast. The use of albuminous yeasts, such as bread yeast, etc., is generally avoided as much as possible, however, as tending to produce lactic and acetic or other objectionable fermentations entirely incompatible with the production of a wine with a delicate flavor.

The temperature at which the fermentation is carried on has a very decided influence upon the character of its product, and the practice differs in different countries in this respect. In California, Spain, South of France, Austria, and Hungary fermentation is conducted at a comparatively high temperature, 15° to 20° C., while in Germany a low temperature, 5° to 15° C., is employed. As with beer, the yeast of either variety of fermentation, high or low, reproduces the same kind of fermentation in musts to which it is added, but the subject of the different ferments as applied to wine has not been so carefully studied as with beer. The high fermentation is said to give a wine rich in alcohol but lacking in bouquet, while the reverse is the case with the low fermentation.

The duration of the fermentation varies with the temperature, the amount of sugar to be transformed, etc.; the completion of the process may be known by the cessation of the disengagement of carbonic acid gas and by the diminution of the specific gravity of the liquid, so that the areometer marks zero or less.

After fermentation is complete, the wine is drawn off from any sediment it may contain into casks or barrels, where a second slow fermentation takes place, continuing sometimes several months. When it is over, the wine is "racked off" into fresh casks, which are closely bunged up. The operation of racking off may have to be repeated several times, and it is sometimes necessary to add isinglass or other gelatinous material, which serves to clarify the liquid, acting on the tannin which it contains. This operation is called "fining."

CHANGES PRODUCED BY FERMENTATION.

The principal change in the chemical constitution of the must produced by fermentation is the conversion of the sugar into alcohol and carbonic acid. One hundred parts of sugar produce 50 parts of alcohol, in round numbers. All the sugar, however, is not converted into alcohol and carbonic acid; a small part is converted into glycerine and succinic acid.

The bitartrate of potash, being insoluble in alcohol, is gradually deposited as the content of alcohol in the wine increases, and forms the substance known as "argol" or crude tartar. This distinctive constituent, tartaric acid, constitutes the superiority of grapes over other fruits for wine-making purposes, the comparative insolubility of its acid salts furnishing a means of removing the excess without the addition of other chemical agents.

Other changes take place, especially during the slow second fermentation, not so well defined or so well understood as those mentioned, but of great importance in their relation to the quality of the final product. These changes, which continue after the fermentation has ended, constitute what is called the "ageing" of the wine and produce its "bouquet" or flavor, generally attributed to the etherification produced by a slow action of the acids upon the alcohols. Wine improves with age, but there is a limit after which it degenerates again and loses its flavor.

METHODS FOR "IMPROVING" WINES.

In France and Germany several methods are in use for increasing the yield of wine or improving its quality. These are especially resorted to in unfavorable seasons, when the want of sufficient sun

prevents the formation of enough sugar in the grape and the proportion of acid is high.

Chaptalization consists in neutralizing the excess of acidity in the must by the addition of marble dust, and increasing the saccharine content by the addition of a certain quantity of cane sugar, which the vintners sometimes replace by starch sugar. In this process the quantity of the wine is not increased, but it becomes richer in alcohol, poorer in acid, and the bouquet is not injured. It is much used in Burgundy.

Gallization, which was invented by a German, Dr. Ludwig Gall, has for its object the production of a standard must, which shall contain a definite proportion of acid and sugar. This is brought about by the analysis of the must and the addition to it of water and sugar, the quantity to be added being ascertained by reference to tables.

Petiotization.—This process, which takes its name from Petiot, a proprietor in Burgundy, is carried out as follows: The *marc* from which the juice has been separated as usual by pressure is mixed with a solution of sugar and water, and the mixture again fermented, the second steeping containing, like the first, notable quantities of bitartrate of potash, tannic acid, etc., which are far from being exhausted by one extraction. The process may be repeated several times, the different infusions being mixed. This process is very largely used in France, and is said to produce wines rich in alcohol, of as good bouquet as the original wine, and of good keeping qualities. It is not allowed to be sold there, however, as *natural* wine.

To what extent these methods obtain in this country I am unable to state. It is probable, however, that they are but little used, as the principal fault found with American wines is their deficiency in bouquet, not in their content of sugar. The detection of wines made in any of the above-mentioned ways is rather a difficult matter chemically, and requires a knowledge of the composition of the pure product only obtained from large numbers of analyses, extending over many years; which data, although existing in abundance in European countries, are, as yet, lacking here, owing to the comparatively recent development of the industry and the small amount of work done on the subject.

PRESERVATION OF WINE.

The method *par excellence* for the preservation of wines is Pasteurization, already alluded to in this report on malt liquors. The temperature employed is from 50° to 65° C., and serves to completely destroy all vegetable life in the wine. When a process so unobjectionable in every way answers its purpose so admirably, it furnishes an additional argument in favor of the legal suppression of all chemical means of arresting fermentation by the use of antiseptics, etc.

VARIETIES.

The different kinds of wines sold can be numbered by the hundreds. They refer usually either to the country where it is produced, or of whose product it is an imitation, as Port, Sherry, Hochheimer, Madeira, etc., or to the variety of grape from which it is made, as catawba, riesling, zinfandel, etc.

No generally recognized classification is made, except into *white* or *red* wines according to their color, and into *dry* or *sweet* wines ac-

cording to their content of sugar. The general name of *champagne* is given to effervescing wines.

COMPOSITION OF WINE.

In countries where the production of wine is one of the leading industries, like France and parts of Germany, the composition of the wines made is very well established. Scarcely any article of consumption has been the subject of so much chemical investigation as wine. Thousands of analyses have been published, so that one is at a loss to choose among them for representative figures.

In a general way the normal constituents of a natural wine may be divided into two classes, volatile and fixed.

The volatile matters are as follows: Water, constituting from 80 to 90 per cent. of the weight; alcohol, 5 to 15 per cent.; glycerine, 2 to 8 per cent.; volatile acids, acetic, œnanthic, etc., constituting one-fourth to one-third of the total acidity; aldehyde, compound ethers, together with the other fragrant, indefinite constituents, which give the wine its flavor and bouquet; carbonic acid gas in small quantities in young wines.

The fixed matters are: Glucose or grape sugar in small quantities in most wines; bitartrate of potash, tartaric, malic, and phosphoric acid, partly free and partly combined with potash, lime, soda, aluminum, magnesium, iron, and manganese, of which salts phosphate of lime is the most abundant, constituting from 20 to 60 per cent. of the weight of the ash, the remainder being chiefly carbonate of potash resulting from the calcination of the bitartrate, with a little sulphate and traces of chlorides. Coloring matters: Pectin and analogous gummy matters; tannin, 1 to 2 per cent. in red wines, mere traces only existing in white.

COMPOSITION OF AMERICAN WINES.

The earliest analyses of American wines on record were made by Merrick,* in 1875, comprising six varieties of California wines.

In October of the same year Mallet and Cooper† published analyses of twelve samples of Virginia wines.

The work of Professor Hilgard on California wines began in 1880 and has continued down to the present day, the results being published in the bulletins of the station. These publications include extensive series of analyses, which afford a most valuable index of the composition of California wines, especially as many of the analyses were made on wines manufactured in the laboratory, and hence known to be absolutely pure. A standard of composition could very properly be established from them, and a limit for the amount of each constituent present in pure wines, by which the addition of alcohol, water, sugar, etc., in sophisticated wines could be detected. The number of different determinations made on each sample is not very large, unfortunately, including only the more important constituents.

As this work seems to be very important as establishing the average composition of pure wines made in California, I have prepared from Professor Hilgard's reports a table showing the maximum, minimum, and mean composition of the pure wines analyzed, as well

* Amer. Chemist, 6, 85. † Chem. News, 32, 160.

as of the wines which were made outside and sent in to the laboratory for analysis :

Maximum, minimum, and mean composition of California wines, as shown by the analyses made at the California State Viticultural Laboratory.

	No. of samples analyzed.	Alcohol, by weight.			Body or extract.			Total acids as tartaric.			Ash.		
		Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum	Mean.
Pure wines made at laboratory in 1884.		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Bordeaux type	10	9.92	7.46	8.81	3.19	2.10	2.57	.633	.381	.510	.447	.252	.352
Burgundy type	6	10.07	6.42	9.01	2.77	1.93	2.36	.765	.450	.624	.425	.200	.319
Southern French and Italian type	18	11.23	7.43	9.26	3.71	1.67	2.56	.585	.395	.506	.511	.234	.343
Dry white wine varieties	13	11.46	7.43	9.71	2.44	1.36	1.90	.600	.423	.516	.342	.157	.219
Sherry and Madeira varieties	10	12.39	7.85	9.68	2.82	1.18	1.85	.660	.217	.498	.390	.160	.288
Port wine varieties	3	10.35	9.05	9.65	3.12	2.36	2.62	.525	.501	.511	.564	.446	.493
Pure wines made at laboratory in 1885.													
Bordeaux type	4	10.54	8.13	9.18	2.99	2.69	2.76	.846	.420	.567	.366	.273	.310
Burgundy type	9	11.46	6.42	8.39	3.07	1.80	2.49	.600	.417	.515	.330	.214	.276
Southern French and Italian type	4	8.84	6.82	7.74	3.07	1.80	2.42	.576	.450	.517	.340	.213	.270
Dry white wine varieties	15	11.23	4.76	9.22	3.82	1.52	2.16	.713	.351	.544	.450	.140	.224
Pure wines made at laboratory in 1886.													
Bordeaux type	15	9.78	6.95	8.28	......	......	......	.810	.420	.620	......	......	......
Burgundy type	16	11.62	7.09	9.21	......	......	......	.940	.350	.540	......	......	......
Southern French and Italian type	15	10.63	6.49	8.48	......	......	......	1.120	.450	.730	......	......	......
Dry white wine varieties	25	9.27	4.14	7.86	......	......	......	.810	.250	.480	......	......	......
Sherry and Madeira varieties	10	11.62	6.35	8.58	......	......	......	.720	.330	.480	......	......	......
American type	3	7.43	6.89	7.14	......	......	......	.740	.500	.620	......	......	......
Wines sent to laboratory for analysis, 1884–'85.													
Reds	20	10.69	7.64	9.63	3.62	2.05	2.87	.750	.395	.563	.534	.219	.340
Whites	5	10.81	8.98	9.80	3.87	2.05	2.67	.527	.397	.473	.367	.255	.303
Wines sent to laboratory for analysis, 1885–'86.													
Reds	55	16.42	7.99	10.48	13.77	2.10	4.30	.879	.225	.554	.470	.230	.324
Whites	16	12.39	8.84	10.82	4.20	1.80	2.66	.750	.210	.473	.300	.170	.261
Zinfandel wines analyzed, 1879–'85	45	12.39	7.43	10.55	8.64	1.46	2.89	.873	.337	.573	.546	.154	.301

In the year 1880 a large number of samples of wine were purchased in the market of Washington and analyzed by the Department of Agriculture. The work was under the charge of the late Henry B. Parsons, one of the most competent analysts ever in the service of the Department. The results are published in the Annual Report for 1880, forming part of the Chemist's report for that year.

The following table gives the averages and extremes of these analyses:

Averages and extremes of American dry wines.

Constituents, etc.	Dry red wines.			Dry white wines.		
	Average (64 analyses).	Highest.	Lowest.	Average (51 analyses).	Highest.	Lowest.
Specific gravity	.9933	1.0011	.9894	.9926	1.0105	.9845
Alcohol, by weight ... per cent.	8.92	12.21	5.71	9.35	13.94	7.03
Alcohol, by volume ... do.	11.04	15.21	7.17	11.70	17.37	8.80
Total residue ... do.	2.28	3.16	1.65	1.75	2.64	1.18
Total ash ... do.	0.231	0.532	0.130	0.181	0.335	0.090
Glucose ... do.	Traces.	0.450	None.	Traces.	0.300	None.
Total acid as tartaric ... do.	0.723	0.997	0.511	0.680	0.855	0.422
Fixed acid as tartaric ... do.	0.360	0.646	0.226	0.313	0.561	0.121
Volatile acid as acetic ... do.	0.290	0.517	0.138	0.294	0.508	0.068

In the work on wines during the present investigation, 70 samples purchased in the market of Washington were examined. Inasmuch as the analyses made in 1880 included so many samples and represented very fairly the composition of the wine sold here, it was thought inadvisable to make a complete analysis of all the samples, especially as many of them were identical in origin with those examined by Mr. Parsons. Accordingly only about one-half the samples (36) were submitted to a very careful and complete analysis, the rest being examined for adulteration only, especially preservatives. Only those samples were chosen for complete analysis which did not correspond to any of the samples analyzed in 1880. The samples are all wines of American origin, of which by far the greater bulk of the wines consumed here consists. Most of the samples are Californian, a few coming from Virginia and other States. Several of the samples had foreign labels, in imitation of some imported wine of the same general class, but in each case the dealer admitted that the wines were American.

The time and scope allowed to the work did not admit of the extension of the investigation to imported wines.

Analyses of wines made by United States Department of Agriculture in 1887.

Designation.	Made in—	Vintage.	Serial number.	Number of analysis.	Specific gravity.	Alcohol, by weight.	Alcohol, by volume.	Extract.	Total acids as tartaric.	Fixed acids as tartaric.	Volatile acids as acetic.	Bitartrate of potash.	Reducing sugars as dextrose.	Glycerine.	Ash.	Polarization in degrees cane-sugar scale.
Red wines.						*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
American Burgundy	....	......	4964	1	.9903	11.93	14.74	1.73	.390	.272	.097	.115	.390	....	.176	±0
Charbono	California	1885	4968	2	.9946	9.12	11.35	2.28	.498	.166	.207	....	.302	....	.324	−1.9
Lenoire	do	1885	4969	3	.9951	10.43	12.96	2.25	.426	.277	.120	....	.354	....	.308	−1.5
Burgundy	do	1884	4995	4	.9945	10.23	12.68	2.00	.870	.724	.121	.062	.093	.730	.255	−1.0
Claret	do	1885	4996	5	.9943	10.61	13.15	2.26	.668	.535	.109	.076	.256	.588	.291	−1.6
Zinfandel	do	1883	5005	6	.9945	9.87	12.22	2.09	.795	.668	.104	.057	.153	.893	.201	+1
Burgundy	....	......	5084	7	.9951	8.29	10.30	1.39	.383	.113	.216	.057	None.	.552	.236	+0.2
St. Julian Claret	California	1885	5088	8	.9983	10.38	12.87	2.83	.728	.404	.211	.062	.508	.466	.289	±0
Claret	Virginia	......	5094	9	.9943	9.04	11.20	1.52	.480	.315	.132	.057	.124	.517	.224	±0
Zinfandel	California	......	5095	10	.9950	8.76	10.87	2.18	.765	.414	.281	.048	.250	.303	.342	−1
Claret	Virginia	......	5096	11	.9958	8.92	11.08	1.71	.525	.297	.183	.095	Trace.	.382	.396	−0.2
Do	do	......	5099	12	.9949	8.43	10.47	1.43	.555	.279	.221	.086	.051	.421	.307	±0
Do	New Jersey	......	5100	13	.9947	9.94	12.31	1.96	.735	.450	.228	.029	.145	.308	.229	±0
Do	Virginia	......	5101	14	.9969	7.78	9.68	1.82	.705	.600	.084	.133	None.	.492	.252	±0
Do	California	......	5103	15	.9923	10.45	12.95	1.71	.668	.443	.180	.029	None.	.370	.453	−0.5
Do	do	......	5104	16	.9937	10.01	12.40	1.82	.585	.393	.154	.048	None.	.348	.360	−0.7
Average	....	......	....	....	.9946	9.66	11.95	1.94	.611	.397	.169	.068	.164	.490	.290	
White wines.																
Moselle	California	1884	4997	1	.9911	10.91	13.52	1.44	.735	.593	.118	.094	.073	.394	.247	−2.2
Riesling, gray	do	1884	4998	2	.9917	9.37	11.61	1.16	.750	.595	.128	.150	.081	.436	.202	−2.4
Riesling, white Johannisburg	do	1885	4999	3	.9919	10.91	13.52	1.75	.563	.451	.092	.039	.325	.797	.203	−2.0
Sauterne	do	1885	5000	4	.9882	13.35	16.52	1.74	.488	.385	.082	.062	.394	.835	.181	−3.2
Dry Catawba	....	......	5081	5	.9913	10.11	12.49	1.16	.683	.448	.156	.198	.147	.370	.240	−1.8
California Riesling	....	......	5083	6	.9914	9.95	12.31	1.16	.690	.471	.175	.189	.130	.427	.260	−0.8
Riesling	....	......	5089	7	.9927	9.01	11.17	1.52	.668	.548	.096	.142	.109	.585	.203	−0.5
Do	California	......	5097	8	.9920	9.64	11.96	1.18	.713	.430	.146	.255	.080	.540	.226	± 0
Berger	do	......	5098	9	.9903	10.74	13.32	1.34	.698	.464	.187	.236	None.	.365	.222	−0.4
Average	....	......	....	....	.9912	10.44	12.94	1.35	.665	.498	.131	.152	.250	.328	.220	......

Analyses of wines made by the United States Department of Agriculture in 1887—Continued.

Designation.	Made in—	Vintage.	Serial number.	Number of analysis.	Specific gravity.	Alcohol, by weight.	Alcohol, by volume.	Extract.	Total acids as tartaric.	Fixed acids as tartaric.	Volatile acids as acetic.	Bitartrate of potash.	Reducing sugars as dextrose.	Glycerine.	Ash.	Polarization in degrees, cane-sugar scale.
Sweet wines.						*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Sherry	California	1883	5001	1	.9929	16.16	19.87	3.82	.638	.445	.157	.039	1.850	.606	.312	−12
Do	...do	......	5090	2	.9939	15.99	19.68	3.3[illegible]	.510	.390	.096	.114	2.8[illegible]0	.278	.215	− 6.6
Port	...do	......	5091	3	1.0432	15.39	18.93	15.38	.683	.431	.202	.076	8.928	.190	.602	−29.2
Sweet Burgundy	...do	1884	5002	4	1.0161	15.53	19.08	9.30	.615	.490	.092	.057	6.150	.657	.415	−30.2
Sweet Catawba	......	1886	5087	5	1.0145	14.50	17.87	8.39	.518	.410	.087	.086	6.650	.113	.118	− 8.8
Do	......	......	5102	6	1.0357	10.98	13.60	13.20	.465	.303	.130	.048	......	.417	.384	......
Tokay	California	1884	5004	7	1.0167	14.58	17.92	9.53	.518	.364	.118	.039	6.110	.206	.262	−20.2
Sweet Muscatel	...do	1884	5003	8	1.0511	12.99	16.05	17.20	.375	.325	.025	.048	15.050	.192	.256	−30.6
Muscatel	...do	......	5092	9	1.0380	15.45	19.00	13.64	.563	.383	.144	.057	11.111	.102	.360	−23.4
Angelica	...do	1884	4994	10	1.0492	12.54	15.49	16.27	.375	.330	.030	.132	14.200	.140	.686	−30.0
Do	...do	......	5093	11	1.0433	15.37	18.90	13.24	.360	.285	.060	.039	11.873	.052	.249	−29.9
Average					1.0261	14.50	17.85	11.21	.511	.378	.104	.067	8.48	.260	.351	......

Maximum, minimum, and mean composition of the samples examined.

Constituents.	Sixteen samples red wines.			Nine samples white wines.			Eleven samples sweet wines.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
Specific gravity	.9983	.9903	.9946	.9918	.9882	.9912	1.0511	.9929	1.0261
Alcohol, by weight .... per cent.	11.93	7.78	9.66	13.35	9.01	10.44	16.16	10.9	14.50
Alcohol, by volume .... do.	14.74	9.68	11.95	16.52	11.17	12.91	19.87	13.60	17.85
Extract .... do.	2.83	1.39	1.94	1.75	1.16	1.35	17.20	3.38	11.21
Total acids as tartaric .... do.	.870	.383	.611	.750	.488	.665	.683	.360	.511
Fixed acids as tartaric .... do.	.724	.113	.397	.595	.365	.49	.490	.285	.378
Volatile acids as acetic .... do.	.281	.084	.168	.137	.082	.131	.202	.025	.104
Bitartrate of potash .... do.	.133	.029	.068	.255	.059	.152	.132	.039	.067
Reducing sugars as dextrose .. do.	.508	none.	.164	.910	none.	.250	15.05	1.85	8.48
Glycerine .... do.	.893	.303	.490	.835	.365	.528	.657	.052	.260
Ash .... do.	.453	.176	.290	.260	.181	.220	.686	.118	.351

THE ADULTERATION OF WINES.

The adulteration of wine has been practiced from a very early date in those countries where the consumption is large. It has increased in amount and in the skillfulness of its practitioners until at the present day it requires for its detection all the knowledge and resources which chemical science can bring to bear upon it, and even then a large part doubtless escapes detection. It must be remembered, however, that in Europe the definition of adulteration has rather a wide scope, including the addition of substances which are simply diluents. The Paris Laboratory considers as a fraud "the addition of any substance for the purpose of gain which changes the composition of the natural wine." In Germany, on account of the northern situation of the country, it is permitted to the wine-growers in bad years, when the grapes contain a relatively high percentage of acid and a low percentage of sugar, to make use of pure sugar as an addition to the must, which addition is not considered as an offense against the adulteration laws, so long as the product is sold as "wine" simply. The amount of water added with the sugar must not be greater than twice the weight of the former, and the product must not be offered for sale as "natural wine."

By far the greater part of the adulteration carried on in the European countries consists of this addition of water (*mouillage*) and sugar (*sucrage*). Such wines result from the methods of manufacture already described—petiotization, gallization, and chaptalization. For the detection of such wines it is necessary to establish maximum and minimum limits for the principal constituents of wines, and the relation in which these constituents stand to one another. To establish these limits is rather difficult, and requires a large series of analyses extending over many years. The constituents most relied on for the establishment of the character of a wine in judging whether it has been diluted or not are, the extract, content of free acid, and the relation between the extract and mineral matters.

The samples which would be considered as watered according to the German standard are as follows: Serial Nos. 5084, 5099, 4997, 4998, 5081, 5083, 5089, 5097, and 5098.

The *plastering* of wines, which is also very extensively carried on in France, consists in adding to the wine or must a large excess of gypsum, or sulphate of lime.

American wines would seem to be quite free from this form of adulteration. In my 70 samples I found none which exceeded the generally adoped standard of .092 gram SO_3 to 100cc., or 2 grams K_2SO_4 to the liter, and only three, Nos. 5100, 5107, and 5115, which contained SO_3 corresponding to over 1 gram K_2SO_4 per liter.

Fortification of wine consists in the addition of alcohol derived from some other source. The alcohol may be added either to the must or the wine. It allows of better incorporation with the wine if it is added to the must before fermentation. In either case, however, it precipitates a part of the constituents originally dissolved, lowers the quantity of extract, deprives the wine of its original bouquet and flavor, and renders it more heady and intoxicating. The least objectionable addition is alcohol distilled from grapes; but the high price of the latter renders it much less likely to be used than corn spirit, which contains considerably more fusel oil. The practice of fortification prevails especially in the more southern wine-growing countries, as Portugal, Spain, and the south of France. Growers in those countries declare it to be a necessary addition in their warm climates for the preservation of the wines, as these latter contain a considerable quantity of unfermented sugar, which would soon produce the souring of the wine if the alcoholic content were not greater than can be obtained by fermentation. In France, for ordinary red wines, the addition of alcohol is decided by the relation of the alcohol to the extract (sugar deducted), exceeding sensibly the relation of 4 to 4.5. In Germany the relation of alcohol to glycerine is relied upon, the maximum proportion allowed being 100 parts by weight of alcohol to 14 of glycerine, and the minimum 100 to 7. Wines going above the maximum are condemned as having suffered an addition of glycerine, those going below the minimum as being fortified with alcohol. With "sweet wines" these figures do not apply, as they are based on natural wines made in Germany.

It is evident that the German standard of 100 parts of alcohol by weight to 7 of glycerine, which is relied upon as a means of detecting the addition of alcohol, can not be applied to American wines. Only three of the samples would pass muster by it, and it seems hardly possible that the practice of adding alcohol could be so wide-spread as would be thus indicated.

Foreign coloring matters are frequently added to red wines, either to brighten and improve the color obtained from the grapes, or, more frequently, to cover up the effects of previous dilution. These colors may be of vegetable origin, obtained from the various vegetable dyes, or by mixing the juice of other highly-colored berries or fruits with the wine; or they may be some of the numerous varieties of aniline dyes obtained from coal-tar. A few examples of the vegetable dyes said to be used may be mentioned as follows: Logwood, cochineal, elderberries, whortleberries, red cabbage, beet-root, mallow, indigo, etc.

All of the samples of *red* wines, about forty, were submitted to a search for aniline coloring matters, which resulted in the demonstration that one sample out of the forty, No. 4996, was colored with an aniline dye-stuff, probably fuchsine.

The *preservative agents* added to wine are entirely similar to those used in malt liquors.

Especial attention has been given in the present investigation to the use of improper preserving agents in fermented drinks. It was thought that such agents were much used; so a considerable number of samples were purchased, and the examination for preservatives, as well as for other adulterations whose detection did not require a complete analysis of the wine, was extended to all. The results show the practice to be even more extensive than was supposed.

The following table shows in what samples salicylic acid and sulphites were detected. In the case of the sulphites, where a "trace" is indicated, there was not sufficient to justify the assertion that a sulphite or sulphurous acid had been added directly to the wine; in such cases it probable came from insufficient cleansing of the casks. Where it is indicated as "present," however, there was sufficient indication of its having been added to the wine.

Examination of wines for preservatives.

Designation.	Made in—	Serial No.	Salicylic acid.	Sulphites.
Champagne	New York	4960	None	None.
Do	do	4961	do	Do.
Do	Ohio	4962	do	Do.
Do		4963	do	Present.
Burgundy		4964	do	None.
Virginia seedling		4965	do	Do.
Catawba	New York	4966	Present	Do.
Sweet Scuppernong	North Carolina	4967	None	Do.
Charbona	California	4968	do	Do.
Lenoire	do	4969	do	Do.
St. Macaire	do	4970	do	Do.
Angelica	do	4994	do	Do.
Burgundy	do	4995	do	Trace.
Claret	do	4996	do	None.
Moselle	do	4997	do	Present.
Riesling, gray	do	4998	Present	None.
Riesling, Johannisberg	do	4999	do	Present.
Sauterne	do	5000	None	Do.
Sherry	do	5001	Present	None.
Sweet Burgundy	do	5002	None	Do.
Sweet Muscatel	do	5003	do	Do.
Tokay	do	5004	do	Do.
Zinfandel	do	5005	do	Do.
Catawba		5081	do	Trace.
California Hock		5082	do	Present.
California Riesling		5083	do	Trace.
Burgundy		5084	do	None.
Zinfandel		5085	do	Do.
St. Julien Claret		5086	do	Trace.
Sweet Catawba	New York	5087	do	None.
St. Julien Claret		5088	Present	Trace.
Riesling		5089	None	Present.
Sherry	California	5090	do	None.
Port	do	5091	do	Do.
Muscatel	do	5092	do	Do.
Angelica	do	5093	Present	Do.
Claret	Virginia	5094	None	Do.
Zinfalden	California	5095	do	Do.
Claret	Virginia	5096	do	Trace.
Riesling	California	5097	do	Present.
California Berger	do	5098	do	None.
Claret	Virginia	5099	do	Do.
Do	New Jersey	5100	Present	Do.
Do	Virginia	5101	None	Do.
Catawba		5102	Present	Do.
Claret	California	5103	None	Do.
Do	do	5104	do	Do.
Do	Virginia	5105	do	Do.
Sauterne		5106	do	Present.
Hock		5107	Present	Do.
California Beaune		5108	do	None.
Sweet Catawba		5109	do	Trace.
California Gutedel		5110	do	Present.
Claret	Virginia	5111	None	Do.
California Zinfalden		5112	do	Trace.
California Port		5113	do	None.
Sonoma Port		5114	Present	Do.
California Angelica		5115	do	Do.

Examination of wines for preservatives—Continued.

Designation.	Made in—	Serial No.	Salicylic acid.	Sulphites.
Frontignan	California	5116	None	None.
Old Pale Sherry	....do	5117	....do	Do.
California Zinfandel		5118	Present	Trace.
Gutedel Hock	California	5119	None	Do.
Berger Hock	....do	5120	....do	Present.
California Burgundy	....do	5121	Present	Trace.
California Madeira	....do	5123	....do	None.
California Port	....do	5124	None	Do.
California Tokay	....do	5125	Present	Do.
California Frontignan	....do	5126	None	Do.
California Angelica	....do	5127	....do	Do.
California Berger Hock	....do	5128	....do	Present.

From an examination of this table it will be seen that of the seventy samples examined, *eighteen*, or over one-fourth, had received an addition of salicylic acid, and *thirteen* had been preserved by the use of sulphurous acid, either as such or in the shape of a sulphite. In two cases both agents had been used. One of the samples which contained salicylic acid and also one containing sulphites were among the samples exhibited at the meeting of the National Viticultural Convention last year in Washington.

CIDER.

Cider is the fermented juice of the apple. It is an article of very general use, especially in those parts of the country where fruit-growing is carried on. Statistics of the amount produced or consumed are rather difficult to obtain, and I am unable to present any definite statement on the subject. It is quite a favorite article of home production, nearly every farmer in regions where apples are grown making his barrel of cider for use through the winter; but a large amount also finds its way into the city markets, finding ready purchasers among people who still retain their taste for the drink, acquired during a childhood on the "old farm." A considerable quantity is also consumed in the shape of bottled cider, "champagne cider," "sparkling cider," and similar substitutes for, or imitations of, champagne wine, large quantities of this clarified cider being produced in some parts of the country, notably New Jersey. Most of the cheaper kinds of champagne (American champagne) are made in this way.

In England and France considerable quantities of cider find their way into the markets, though it is there, as here, largely an article of home consumption. Certain parts of those countries are famous for the quality of their ciders, notably Normandy, in France, and Herefordshire and Devonshire, in England. France produced, in 1883, 23,493,000 hectoliters (620,211,200 gallons) of cider, or over one-half of the quantity of wine produced, and three times as much as the total quantity of malt liquors.

MANUFACTURE OF CIDER.

In the numerous sections of the United States where apples are grown in large quantities the manufacture of cider furnishes a most important means for the utilization of such fruit as is unfit for marketing, either from being too small or sour, or too thoroughly ripened, or bruised from handling. The conversion of these into cider, and

perhaps of the cider into vinegar, is a very important branch of apple-growing, and the cider press is an indispensable adjunct to a large orchard. Within the last ten years the manufacture of cider has been greatly aided by improvements, both in the machinery for crushing the fruit and in the presses for extracting the juice, but it is doubtful if the methods of treatment of the juice after extraction have undergone a corresponding development. The methods of fermentation and preserving—operations that are so carefully performed in the manufacture of other fermented liquors—are exceedingly crude, as I can testify from personal experience. The juice, whether containing a relatively large percentage of sugar or not, is drawn into barrels and left to itself, probably exposed to a hot sun and to all the changes of temperature incident to the autumn season; and when the season is over or the cider is in danger of freezing, it is transferred to the cellar in the same barrels in which it was originally run, without any attempt at cleansing it of sediment, or filtering or racking; and when any attempt at improving its keeping quality is made it is by adding some antiseptic instead of freeing it from the matters which conduce to improper fermentations, or so conducting the process as to produce a liquor which can properly be called the "wine of apples." It seems remarkable that with these methods so palatable a drink is produced, a fact which only shows what might be done if a little care and scientific knowledge were applied to the treatment of the juice. There is a great difference between the practice here and in other countries in regard to the treatment of the juice. Here the greater part of the cider produced is treated as indicated above, and is sold to the consumer in the fall or winter of the same year it is produced, without any treatment whatever, except perhaps the addition of a dose of mustard seeds or sulphite of lime or salicylic acid, to arrest or retard the fermentation. This addition serves only to stop the fermentation for a while, probably through the winter, and in the spring whatever has not been consumed has to be thrown away or turned into vinegar. In England and France the juice is treated according to the sweetness of the apples from which it is made, very sweet juice requiring a low temperature for its fermentation, in order that the operation shall not be too rapid. The juice is run into barrels or large vats, which are kept in a barn or cellar where the temperature is more or less constant, and the fermentation allowed to go on until a "chapeau" or head of scum forms on top, containing many of the impurities of the juice. The clear liquid is then "racked off" from between the impurities which have risen to the top and those that have fallen to the bottom. The casks into which it is received are scrupulously clean and are filled nearly full and transferred to a cooler cellar, where a second slow fermentation takes place. The racking-off process may be repeated if necessary, or the juice may be filtered from the first fermentation. Cider fermented and properly racked in this way will keep indefinitely at a low temperature, especially if bottled. For bottling, it generally undergoes the operation called "fining," by the addition of isinglass, which removes most of the albuminous constituents which are so inimical to its proper preservation. Cider made in this way will be much richer in alcohol and contain much less acetic acid than when its first fermentation is allowed to take place at a high temperature and in a rapid, tumultuous manner. It is a true apple wine and will keep indefinitely. The cider of Devonshire has been kept twenty or thirty years.

COMPOSITION OF CIDER.

The amount of chemical work done on cider is not nearly so great as has been done on wine. In fact, the published analyses of cider are very few and are confined almost entirely to other countries. I have not been able to find a single published analysis of American cider.

Various conditions rendered it impossible to extend the present investigation of ciders to a very large number of samples. It is hoped that an opportunity for a more extended study will present itself in the future.

The samples for the investigation were purchased in the city in the same way as the samples of wine and beer.

Analyses of ciders by United States Department of Agriculture.

Designation.	Serial number.	Number of analysis.	Specific gravity.	Alcohol, by weight.	Alcohol, by volume.	Total solids.	Free acids, as malic.	Sugar, as dextrose.	Ash.	Albuminoids.	Carbonic acid.	Polarization, cane-sugar scale.
Well-fermented ciders.				*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct*	°
Draught cider ("extra dry")	4830	1	1.0132	4.18	5.23	3.31	.602	(*)	.396	.038	....	—19.5
Bottled cider, known to be pure	4832	2	1.0003	8.09	10.05	1.88	.456	......	.279	.063	(†)	—7.0
Bottled cider	4833	3	1.0007	6.28	7.83	1.80	.376	......	.340	.044	....	—6.1
Bottled "extra dry russet" cider	4834	4	1.0264	4.48	5.61	5.52	.339	......	.393	.031	....	—35.2
"Champagne cider," bottled	4835	5	1.0223	4.08	5.10	5.02	.567	......	.310	.050	.161	—23.4
Do	4836	6	1.0143	5.45	6.79	3.69	.361	......	.415	.038	.120	—20.4
"Sparkling cider," bottled	4927	7	1.0306	3.63	4.54	5.92	.113	......	.506	......	(‡)	—33.8
Average	......	....	1.0154	5.17	6.45	3.88	.402	......	.377	.044	....	......
"*Sweet*" *or incompletely-fermented ciders.*												
Draught cider	4829	1	1.0537	0.65	0.81	9.34	.565	......	.315	.069	....	—41.6
"Sweet" cider	4831	2	1.0516	0.61	0.77	9.59	.302	......	.270	.063	....	—34.2
"Sweet" cider (draught)	4837	3	1.0567	0.20	0.25	9.53	.375	......	.283	.075	....	—48.4
Do	4838	4	1.0203	3.46	4.33	3.84	.302	......	.374	.044	....	—24.2
Do	4839	5	1.0552	0.55	0.67	9.75	.409	......	.336	.031	....	—48.5
Do	4841	6	1.0355	2.96	3.71	6.98	.478	......	.348	.069	....	—39.1
Average	......	....	1.0455	1.40	1.76	8.17	.405	......	.321	.059	....	......

* A circumstance arising after the samples had been thrown away seemed to throw considerable doubt upon the determinations of sugar, which were made by an assistant, and the entire set had to be thrown out.

† Trace.

‡ Determinations of the carbonic acid in three different bottles gave the following results: .728, .654, .482.

ADULTERATION OF CIDER.

Cider is very little subject to adulteration, according to most of the authorities on foods. Even Hassall, who generally enumerates under each article of food a list of every conceivable adulteration that has ever been found or supposed to have been used in such food, only speaks of the addition of water, of burnt sugar as a coloring matter, and of the use of antacids for the correction of the acidity of spoiled cider. On the other hand, in France, where, as we have seen, it is very largely consumed, its adulteration is by no means uncommon, although principally confined to its watering, together with additions for the purpose of covering up such attenuation, such as foreign coloring matters. In the Paris municipal laboratory, out of 63

samples examined in 1881, 39 were pronounced "bad," among which were 26 artificially colored; in 1882, 59 samples were examined, of which 30 were declared "bad," of which 7 samples were artificially colored; 2 samples contained salicylic acid. The following is considered there as a minimum limit for the composition of a pure cider, and any sample which falls below it in any constituent is considered as watered:

Alcohol, per cent., by volume	3
Extract in grams, per liter	18
Ash	1.7

This is for a completely-fermented cider; in sweet ciders the content of sugar should exceed the limit sufficiently to make up for the deficiency of alcohol, to which it should be calculated.

EXAMINATION OF THE SAMPLES FOR ADULTERATION.

The investigation of the samples was undertaken with the full expectation of finding a considerable number preserved with antiseptics. This supposition failed to be confirmed, however, for no salicylic acid was found, and in but one case was any test obtained for sulphites. None of the samples fell below the standard proposed by the French chemists, given above, and no metallic or other adulteration was discovered.

The single exception, however, No. 4927, was an embodiment in itself of nearly all the adulterations which have been enumerated as possible in cider. It was handsomely put up in neatly-capped bottles, and of a clear, bright color. Its tremendous "head" of gas when uncorked gave rise at once to the suspicion that it had received some addition to produce an artificial pressure of gas, for pure cider does not contain sufficient sugar to produce very much after-fermentation, any more than pure wine. The low content of free acid, together with the large amount of ash and very variable content of carbonic acid in different bottles, established the fact that bicarbonate of soda had been added, probably a varying quantity to each bottle, while the dose of sulphites added was so large that a bottle has stood open in the laboratory all through the summer without souring.

ABSTRACT OF REPORT OF RESULTS OF EXPERIMENTS WITH MANUFACTURE OF SUGAR FROM SORGHUM AND SUGAR CANES.

EXPERIMENTS WITH SORGHUM AT FORT SCOTT.

Report of MAGNUS SWENSON.

PRELIMINARY EXPERIMENTS.

As soon as the earliest of the amber cane approached ripeness a large number of preliminary experiments were made in defecation and filtration of juices. The experiments in filtration were made with a small filter press with a hand pump. The cloth used was the same as that used in the large presses, and every precaution was

taken to make the results just as valuable as if made on a larger scale. These experiments were begun on July 29. The filtering materials used were finely-powered lignite, bituminous coal, shale, several kinds of soils, and prepared carbonate of lime. The following conclusions were derived from these experiments:

(1) None of the above materials would filter juice satisfactorily that had an acid reaction.

(2) Neutral juice filtered very slowly and a hard-press cake would not form in the press.

(3) With a decidedly alkaline juice the filtration took place much more readily, but was not entirely satisfactory except with carbonate of lime.

(4) Lignite did not have any apparent decolorizing effect on the juice except when the juice had become highly colored by adding an excess of lime, when a slight decolorization took place. A large number of experiments were made with varying quantities of lignite, but in no case did it show any superiority over fine, sandy loam either as a decolorizer or filtering medium.

Experiments for testing the cutting, cleaning, and elevating machinery were also conducted as early as the condition of the cane would permit.

The method of unloading the cane and getting it onto the carrier was similar to that employed last year. The seed heads, however, were cut off in the field. The cutters were made by the Belle City Manufacturing Company, of Racine, Wis. They did the work well, but the machines were too light to stand the very severe work they were called upon to do.

The cane was cut into pieces about an inch long and then elevated by a drag to the top of the series of four fans standing straight over each other, each fan being furnished with a separate set of shakers. The cleaning apparatus, after considerable adjustment, did fairly good work. The leaves and sheaths were removed by a suction fan. The cleaned pieces of cane were cut by a rapidly-revolving cutter, consisting of a cylinder carrying 30 knives. The cylinder was made up of three separate sections, each with 10 knives. Although no difficulty was encountered in cutting, the work of the cutter was very unsatisfactory. A large portion of the chips consisted of long pieces with the bark on one side. Diffusion in this case could take place but in one direction, and in the largest chips of this kind the extraction of the sugar was very imperfect. The drag for conveying the chips to the cells was rebuilt and placed higher and on one side of the battery so as not to interfere with the packing of the chips in the cells. The exhausted chips were dumped directly into a car running on rails under the battery. This car was run up an incline onto a trestle work about 20 feet from the ground, by the aid of an endless cable. Two friction clutches, running in opposite directions, served to run the car forward or backward, and the car was so arranged that the charge of exhausted chips could be dropped at any point by simply reversing the motion of the cable.

EXPERIMENTS WITH CRUSHER.

It was the opinion of a number of men interested in this industry that a very much larger yield and better quality of juice could be obtained by the crushers if the cane, previously to being pressed, were cleaned and macerated, and it was deemed best to give the matter

a thorough trial. For this purpose a 3-foot cane mill was purchased from J. A. Field & Co., of Saint Louis. It consisted of a 3-roller mill and a supplemental 2-roller mill. The principal trouble encountered was in feeding the mill. Even with an arrangement for forcing the chips between the rolls not over 3 tons per hour could be forced through, and the yield of juice was but little if any greater than when whole cane was fed to the mill.

The average yield of sirup was about 10 gallons per ton of cane worked. The same kind of cane yielded by diffusion 25 gallons of sirup per ton of cane. The cane used in this trial was very poor, being mostly lodged. These experiments show conclusively the great superiority of the diffusion process for sirup making, a very good quality of sirup being produced from very poor cane. It was superior in both color and flavor to the sirup from the mill juice. The juices from the mill and battery were treated precisely alike and they were skimmed and evaporated in an open steam evaporator. This is a matter of great importance to all engaged in the sugar business, as both at the beginning and close of the season there will be considerable cane that is not fit for sugar-making, and the fact that 25 gallons of first-class sirup can be made from such cane by diffusion makes it possible to work even such material at a good profit.

The first run for sugar was begun on August 26. The juice was made alkaline with lime, and about 2 per cent. of carbonate of lime was added. It was then filtered. To other portions of juice, instead of carbonate of lime, 3 per cent. of ground shale, bituminous coal, and sandy loam were added respectively. The filtrations were very imperfect except with the carbonate of lime and in every way corresponded with the preliminary experiments. Lignite was not used on a large scale because I had at the time no means of grinding it; but judging from a large number of experiments made in the beginning of the season, it is safe to conclude that it would not have filtered any better than the other materials used.

Satisfactory filtrations were only produced when the juice had been made strongly alkaline, and no material was found which would filter the juice when left slightly acid.

On August 30 the first strike was made, and the yield was a little more than 100 pounds of washed sugar per ton of clean cane.

INVERSION OF CANE SUGAR.

To prevent the inversion of the sugar in battery, about 10 pounds of dry precipitated carbonate of lime was mixed with enough water to produce a thin paste. This was added to the fresh chips while the cell was being filled, and entirely prevented any loss of sugar by inversion.

The carbonate was made by forcing carbonic acid gas by the aid of a pump into thin milk of lime. The injection pipe was perforated and lay along the bottom of a 10 by 10 foot tank containing the milk of lime. The gas was produced by burning coke in a small furnace. When the lime showed but a slight alkaline reaction it was run off into a large hole in the ground where the water soon drained away, leaving the carbonate nearly dry.

EXPERIMENTS WITH DEFECATION.

On September 1 filtration was dispensed with and experiments tried with simple defecation. The defecators were similar to those in

ordinary use, being simply round tanks with conical bottoms and furnished with coils for heating the juice. This method of defecation, however, was not satisfactory, and defecation was tried in a shallow pan 16 feet long and 26 inches wide, with a partition running lengthwise in the center, the inlet and outlet for the juice being on the same end of the pan on opposite sides of the partition.

This pan was gotten up very hurriedly and was supplied with iron pipes for heating the juice. The juice, after being previously limed and somewhat heated, was pumped into one side of the long heating pan and run out at the opposite side continuously.

Being compelled by the center partition to flow down one side and back on the other, the juice made a circuit of 32 feet. The steam was so regulated that during the first 16 feet it was gradually brought to the boiling point, while in the opposite side it boiled vigorously. In this way a strong current was produced which carried all the impurities in the form of scum to the quiet portion of the juice, where it was removed and returned to the battery, thus avoiding all waste and annoyance from this source.

EVAPORATION.

The juice was evaporated to from 20° to 30° Baumé, in a double-effect evaporator built by the Pusey & Jones Company, of Wilmington, Del. This apparatus gave perfect satisfaction. All the evaporation was done by exhaust steam of 4 pounds pressure, a small amount of live steam being used only when part of the machinery was stopped.

EXPERIMENTS IN BOILING TO GRAIN.

Every strike was boiled to grain in the pan. Several experiments were made to ascertain the result in boiling "in and in," the juice being enriched by the addition of sugar made from previous strikes. It is very doubtful, however, whether this is to be recommended, excepting when the juice is so poor that a good grain can not be obtained in any other way.

Owing to the fact that we were unable to secure a sufficient supply of cane the work progressed very irregularly. Only twice during the entire season was the battery kept in operation continuously for twenty hours, and during the sugar-making season the diffusion battery was emptied sixty-two times. This entailed no inconsiderable loss, amounting to from 1 to 2 tons of clean cane each time a stoppage occurred.

CANE WORKED FOR SUGAR.

The total amount of cane worked for sugar was 2,610 tons. In this is included all that was used for experiments in filtration and defecation during the first part of the season. I have no record of the exact amount lost in this way. The total amount of first sugar made was 235,476 pounds. This sugar was all washed, and polarized on an average 96 per cent. The total amount of molasses produced was 51,000 gallons.

TRIAL RUNS.

In order to ascertain as nearly as possible the average yield of sugar per ton of cane two trial runs were made.

FIRST TRIAL.

On September 15 a strike was made from 133 tons of clean cane. In order to obtain a better grain 2,600 pounds of sugar were added to the juice after it had been defecated; 2,200 pounds of juice were drawn from each cell.

The following is a record of this experiment:

Sucrose in mill, juice from chips		10
Glucose in mill, juice from chips		3.41
Solids not sugar, juice from chips		3.20
Ratio of sucrose to glucose		2.94
Co-efficient of purity		60.3
Sucrose in diffusion juice		7.91
Glucose in diffusion juice		2.60
Solids no tsugar, diffusion juice		2.59
Ratio of sucrose to glucose		3.04
Co-efficient of purity		60.4
Sucrose in defecated juice		8.34
Glucose in defecated juice		2.4
Solids not sugar, defecated juice		2.46
Ratio of sucrose to glucose		3.47
Co-efficient of purity		63.6
Total weight of first sugar	pounds	17,608
Sugar added to juice	do	2,600
Total yield of first sugar	do	15,008
Total yield of second sugar	do	2,33
Total yield of molasses	gallons	2,22
Yield per ton:		
First sugar	pounds	113
Second sugar	do	17.5
Molasses	gallons	15.5
First sugar polarized		93
Second sugar polarized		88.7

Temperature in battery was between 75° and 80° C.

SECOND TRIAL.

Eighty-six tons of clean cane were worked—54 tons on October 1 and 32 tons on October 2. All was boiled in one strike. No analyses were made on October 2, and unfortunately the complete data can not therefore be given. The juice was not enriched as in the previous trial.

The following are the results:

Yield of first sugar	pounds	9,292
Yield of second sugar	do	1,988
Yeld of molasses	gallons	1,462
Yeld per ton:		
First sugar	pounds	108
Second sugar	do	23
Molasses	gallons	17
First sugar polarized		97
Second sugar polarized		88

AVERAGE YIELD OF SUGAR.

Making a fair allowance for cane and juice lost in experiments during the first part of the season, the average yield of first sugars will be fully 100 pounds per ton, polarizing 97. A strike of average molasses boiled to string proof yielded 12½ per cent. of the weight of the *masse cuite* in sugar, containing 88 per cent. of sucrose. This is at

the rate of 28 pounds per ton of cane. Had the entire crop been boiled for seconds the average yield per ton of cane would not have been less than 128 pounds of sugar and 16 gallons of molasses. From a financial standpoint the advantage of working for seconds depends entirely on the sirup market. In my judgment it would not have paid this season, as the market is better than for years past. The entire product of 51,000 gallons has already been sold at a good price.

AVAILABLE SUGAR.

It is at once apparent that the old method of calculating available sugar must be abandoned. According to this rule there would be but 61.6 pounds available sugar per ton of cane in the diffusion juice of the first trial, when as a matter of fact 130½ pounds were obtained. It would therefore seem that instead of preventing an equal weight of cane sugar from crystallizing, the glucose and other solids not sugar in the juice prevented only two-fifths of their weight of cane sugar from crystallizing. This is also borne out by the data furnished by the analysis of the juices during the entire season.

Average analyses from tables prepared by Dr. Crampton.

For week ending—	Mill juices.			Diffusion juices.			Total sugar exhaust chips.
	Brix.	Sucrose.	Glucose.	Brix.	Sucrose.	Glucose.	
September 17	16.9	9.99	3.46	12.8	7.74	2.28	.99
September 24	17.3	9.63	3.52	12.2	6.88	2.35	.96
October 1	16.4	9.41	3.24	10.9	6.34	2.21	.63
October 9	16.4	9.96	3.38	11.0	6.60	2.31	.98
October 16	14.8	9.34	2.98	10.1	6.38	1.90	1.10
Average for season	16.3	9.67	3.31	11.4	6.79	2.21	.93

Average ratio of sucrose to glucose in mill juices	2.92
Average co-efficient of purity of mill juices	59.3
Average ratio of sucrose to glucose in diffusion juices	3.07
Average co-efficient of purity of diffusion juices	59.5

The above table discloses two very important facts:

(1) The very uniform condition of the cane throughout the entire season.

(2) By the use of a small quantity of carbonate of lime in the cells the inversion of cane sugar is entirely prevented.

The amount of sugar left in the chips is larger than it ought to be. This is due, as previously stated, to the bad shape of some of the chips. For this reason the juice was also more dilute, as larger charges had to be drawn in order to get a more complete extraction. Up to September 22 the amount drawn was 2,200 pounds. From this to October 4, 2,640 pounds, and from October 4 to the end of the season 2,420 pounds were drawn.

The temperature of the battery was maintained near 80° C.

EFFECT OF HEAT.

In order to determine the amount of inversion taking place when the juice was evaporated to sirup, in an open pan, the following experiments were made. Juice was boiled down in the open pan used for defecating, and samples taken at different intervals.

The following are the analyses:

Brix.	Sucrose.	Glucose.	Ratio of sucrose to glucose.
13.0	8.08	2.39	3.38
21.7	13.49	3.87	3.48
27.7	33.30	9.59	3.50
	37.20	11.36	3.27
	41.10	lost.	

[Trial on Porter's evaporator.]

Sucrose.	Glucose.	Ratio of sucrose to glucose.
6.71	2.04	3.44
39.20	11.80	3.32
50.00	15.26	3.21
51.00	15.88	3.21

The juice in both cases was made as nearly neutral with lime as possible.

It seems from the above that the invertive action of the heat has been greatly overestimated, and that when the juice is not acid no appreciable inversion takes place even when the juice is reduced to a moderately heavy sirup in an open pan.

From Mr. Parkinson's report it will be seen that the loss in leaves and sheaths amounted to about 11 per cent. of the weight of the topped cane. This loss can no doubt be somewhat reduced when the cleaning machines become better adapted to the work.

According to a number of trials with freshly-cut cane the weight of leaves and sheaths amounted to 10 per cent. and the seed tops to 15 per cent. of the weight of the whole plant. Late in the season when the leaves become dry this proportion is of course considerably less.

COST OF A FACTORY.

A very important fact to determine is the capacity and cost of a factory that will work the cane most economically. There can be no doubt but the advantages are greatly on the side of the large factory. The office expenses and cost of management will be but little, if any, greater. All the machinery required in a large factory is equally necessary in a small one, and the proportionate price of this machinery is in favor of the larger factory. In other words, a factory working 200 tons of cane per day will cost much less than double the cost of a factory working 100 tons. Again, the cost of operating a large factory is proportionately much less. It takes no more men to operate a diffusion battery with a capacity of 200 tons of cane than one half as large, and this is true of the larger part of the machinery in the factory. A point may of course be reached where the size of the machinery becomes too large for economical working, and when the amount of cane needed for working will be greater than can be grown within easy reach of the factory.

Judging from our present knowledge, a factory capable of working from 200 to 250 tons of cleaned cane per day seems the most desirable. This would require a diffusion battery of 12 cells, each cell having a capacity of 112 cubic feet. The evaporating apparatus should have a capacity of 250 tons of water per day and a strike pan with a pro-

portionate capacity. The cost of such machinery will, of course, depend largely on its kind and quality, and can be readily obtained from any reliable manufacturer. The cost of a factory is almost always underestimated, owing to many items which are not taken into account. The capital for building a factory of the above capacity should not be less than $100,000 to $125,000, anything below being certainly unsafe. Nothing but the best machinery should be used and every precaution should be taken to prevent breakage of machinery and to be able to make repairs quickly by having duplicate parts of such machinery as are liable to break. There is no manufacture which depends more for its success on the proper working of the machinery than the sugar industry.

COST OF WORKING.

The success of this industry does not depend altogether on how much sugar can be produced per ton of cane, but the cost of this production must also be considered.

There is no doubt but that $2 per ton for working cane are sufficient to cover all legitimate expenses connected with the manufacture.

UTILIZATION OF THE EXHAUST CHIPS.

It will soon become a matter of necessity to dispose in some way of the exhausted chips from the battery.

The great amount of this material accumulating about the factory makes it imperative that they be utilized in some way. Three methods of disposition have been suggested: (1) To return them to the land as a fertilizer; (2) to use them for fuel; (3) to manufacture into paper pulp. One of the last two methods will no doubt be adopted. Some experiments in using for fuel were made during the season. A large portion of the water was pressed out by passing the chips through a 3-foot cane-crusher. The chips dropped from the last roll into a hopper, from which they were taken up by a suction-fan and blown over to the boiler-house. This method of handling the chips has many features to recommend it. It is very simple, and, besides, the chips are dried somewhat by being subjected to the strong current of air. No doubt the making of paper pulp from the chips will become the most profitable disposition to make of them. The cane, after being reduced to fine chips and thoroughly washed in the diffusion battery, is certainly in an excellent condition for this work. No attempts have been made, as far as I know, to make paper pulp on a large scale from this source, but very fine samples of pure white pulp have been made in a small way. This matter is certainly deserving of thorough investigation.

NEEDS OF THE INDUSTRY.

One of the greatest difficulties which will be encountered by those engaged in developing this industry will be the scarcity of men capable of operating factories. This will be the most serious hindrance to rapid development, as nothing but time can produce men of the requisite experience. The establishment of a school for training young men in this work would be of inestimable value. Here they should receive thorough technical training, which should be supplemented with a drill in the factories while they are in operation. This would in a short time develop a number of men capable not

only of taking charge of a factory, but also qualified to conduct independent research, which, in so fruitful a field, could not but result in great good to the industry.

The improvement of the sorghum cane is also one of the subjects which should receive immediate attention.

Although very little has been attempted in this line, enough has been done to show that the cane sugar is greatly increased by good culture, and that it is susceptible of very great improvement by the various methods known to scientific agriculture there can be no doubt. The idea that sorghum cane will grow anywhere and do well with any kind of treatment is one of the main causes of poor cane. Instead of receiving thorough culture, it generally gets only such attention as can be spared from the other crops. If the price paid for cane could be regulated by the actual amount of sugar it contained, the farmer would soon find it to his advantage to devote more time to his cane-field.

The establishment of a sugar refinery within easy reach of the sorghum-sugar factories will be one of the imperative needs in the near future. The demand for any kind of sugar but white granulated is comparatively limited. The sugar produced at Fort Scott averaged within 2½ per cent. of being as pure as the best granulated, while the selling price has been about 1½ cents per pound less, or a difference of about 25 per cent. The most feasible manner of conducting the refinery, at least in the near future, will be to supply one or more factories with the additional appliances needed, and when the season's work is over the sugar from a number of factories could be refined there during the balance of the year.

CONCLUSIONS.

In reviewing the work the most important point suggested is the complete success of the experiments in demonstrating the commercial practicability of manufacturing sugar from sorghum cane.

(2) That sugar was produced uniformly throughout the entire season.

(3) That this was not due to any extraordinary content of sugar in the cane, but, on the contrary, the cane was much injured by severe drought and chinch-bugs.

(4) That the value of the sugar and molasses obtained this year per ton of sorghum cane will compare favorably with that of the highest yields obtained in Louisiana from sugar-cane; and, taking into consideration the much greater cost of the sugar-cane, and that it has no equivalent to the 2 bushels of seed yielded per ton of sorghum cane, also our much cheaper fuel, I say without hesitancy that sugar can be produced fully as cheaply in Kansas as in Louisiana.

M. SWENSON.

SUMMARY OF CHEMICAL WORK DONE AT FORT SCOTT, 1887, *UNDER DIRECTION OF THE CHEMIST OF THE DEPARTMENT.*

[By C. A. CRAMPTON and N. J. FAKE.]

Analyses were begun on the 3d of September, but a full chemical control of the work was not established until the 8th.

Samples of the fresh chips, diffusion juices, and exhausted chips were taken in the usual way, great care being taken to have them represent as accurately as possible the mean properties of the several substances mentioned.

TABLE 1.—*Analyses of juices of fresh chips.*

Number of analyses	55
Sucrose:	Per cent.
Mean	9.54
Maximum	11.51
Minimum	1.39
Glucose:	
Mean	3.40
Maximum	6.49
Minimum	6.20
Total solids (spindle):	
Mean	16.14
Maximum	17.18
Minimum	13.09

TABLE 2.—*Diffusion juices.*

Number of analyses	51
Sucrose:	Per cent.
Mean	6.68
Maximum	8.79
Minimum	5.05
Glucose:	
Mean	2.26
Maximum	3.07
Minimum	1.75
Total solids (spindle):	
Mean	11.08
Maximum	13.10
Minimum	8.64

TABLE 3.—*Exhausted chips.*

Number of analyses	29
Both sugars:	Per cent.
Mean	1.03
Maximum	1.83
Minimum	.49

TABLE 4.—*Clarified juices.*

Number of analyses	25
Sucrose:	Per cent.
Mea	6.91
Maximum	8.25
Minimum	5.11
Glucose:	
Mean	2.19
Maximum	2.85
Minimum	1.69
Total solids (spindle):	
Mean	11.31
Maximum	13.35
Minimum	8.94

TABLE 5.—*Sirups.*

Number of analyses	14
Sucrose:	Per cent.
Mean	29.90
Maximum	41.90
Minimum	16.10
Glucose:	
Mean	10.06
Maximum	16.26
Minimum	7.52

Total solids (spindle):	Per cent.
Mean	46.02
Maximum	60.40
Minimum	36.20

TABLE 6.—*First sugars.*

Number of analyses	28
Sucrose:	Per cent.
Mean	95.64
Maximum	98.10
Minimum	92.40

TABLE 7.—*Second sugars.*

Number of analyses	3
Sucrose:	Per cent.
Mean	85.80
Maximum	88.70
Minimum	82.30

The analyses of the molasses, masse cuites, and some other products are not yet complete, but will be given in full in Bulletin No. 18.

The ratio of sucrose to glucose in the fresh chips and diffusion juices for the season was as follows:

Mill juice	1 : 2.80
Diffusion juice	1 : 2.95

This would seem to show one of two things, either that there was absolutely no inversion in the battery or that the glucose in the cane was not so readily diffused as the sucrose. The latter hypothesis seems to be borne out by the analyses of the exhausted chips, as shown in the following table of analyses:

Sucrose and glucose in juice from exhausted chips and corresponding diffusion juices.

Date.	Exhausted chips.			Diffusion juices.		
	No.	Sucrose.	Glucose.	No.	Sucrose.	Glucose.
		Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
Oct. 8	243	.78	.57	247	5.90	3.06
Oct. 11	260	.87	.51	259	6.58	2.09
Oct. 12	267	.63	.29	266	6.17	2.03
Oct. 13	280	.95	.48	279	5.97	1.89
Oct. 14	289	.52	.24	288	6.02	1.80
Oct. 15	294	.75	.27	293	5.66	1.75
Oct. 18	313	.99	.43	312	5.66	2.02
Average	......	.78	.40	......	5.99	2.09

ABSTRACT OF REPORT OF E. B. COWGILL.

HISTORICAL SKETCH.

The sorghum plant was introduced into the United States in 1853–'54 by the Patent Office, which then embraced all there was of the United States Department of Agriculture. Its juice was known to be sweet, and chemists were not long in discovering that it contained a considerable percentage of some substance giving the reactions of cane sugar. The opinion that the reactions were due to cane sugar received repeated confirmations in the formation of true cane-sugar crystals in sirups made from sorghum. Yet the small amounts that were crystallized, compared with the amounts present in the juices

as shown by the analyses, led many to believe that the reactions were largely due to some other substance than cane sugar.

EARLY INVESTIGATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

During the years 1878 to 1882, inclusive, while Dr. Peter Collier was chief chemist of the Department of Agriculture, much attention was given to the study of sorghum juices from canes cultivated in the gardens of the Department, at Washington. Dr. Collier became an enthusiastic believer in the future greatness of sorghum as a sugar-producing plant, and the extensive series of analyses published by him attracted much attention from sugar-makers in the South and students of the chemistry of sugar throughout the country.

SUGAR FACTORIES ERECTED IN KANSAS.

Stimulated by the analytical results published by Dr. Collier, interested parties erected large sugar factories and provided them with costly appliances. Hon. John Bennyworth erected one of these at Larned, in this State. S. A. Liebold & Co. subsequently erected one at Great Bend. Both of these factories made some sugar, both lost money, and both quit the business.

Sterling and Hutchinson followed with factories which made considerable amounts of merchantable sugar at no profit.

INFORMATION GAINED.

Much valuable information was developed by the experience in these several factories, but the most important of all was the fact that, with the best crushers, the average extraction did not exceed half of the sugar contained in the cane.

FURTHER WORK OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

In 1883, Prof. H. W. Wiley, chief chemist of the Department of Agriculture, made an exhaustive series of practical experiments in the laboratories of the Department on the extraction of the sugars from sorghum by the diffusion process. His report sums up the results of his experiments as follows:

(1) The extraction of at least 85 per cent. of the total sugars present was secured. In many of the experiments, as will be seen by consulting the table, scarcely a trace of sugar could be detected in the exhausted chips.

(2) The production of a quantity of melada represented by from 10.9 to 12.28 per cent. of the weight of the cane diffused.

This was secured with a cane in which the total sugars did not excede 11.68 per cent. The percentage of melada by this process will be found just about equal to the per cent. of total sugars in the cane.

It ought to be greater with a more perfect extraction, but I am speaking only of results actually obtained.

This yield is just about double that obtained by the large factories at Rio Grande, Champaign, and other places.

(3) The production of a juice of great purity, which lends itself easily to processes of depuration.

I consider the experiments, however, to have their chief value in the fact that they will call the attention of cane-growers to the advantages which a rational system of diffusion will have over pressure in the extraction of the saccharine matter.

I hope to be able at the end of another season to report further progress in this interesting problem.

In the present condition of the sorghum-sugar industry, in which it has alike to be protected from the overzeal of its friends and the opposition of its enemies, the process of diffusion offers the most promising outlook for success. It therefore seems the duty of this division to make a more practical test of this process and on a larger scale.

To make the necessary further experiments with diffusion required the expenditure of large sums of money. As already shown, the private companies had lost heavily. They were utterly unable to complete the experiments so hopefully begun by the Department of Agriculture.

ANOTHER APPROPRIATION.

In 1885, Senator Plumb again labored for an appropriation for experiments with diffusion. Fifty thousand dollars for this purpose was again added to the agricultural appropriation bill, on the amendment of Senator Plumb. This was expended at Ottawa, Kans., and in Louisiana. The report of the work at Ottawa closes as follows:

(1) By the process of diffusion 98 per cent. of the sugar in the cane was extracted, and the yield was fully double that obtained in the ordinary way.

(2) The difficulties to be overcome in the application of diffusion are wholly mechanical. With the apparatus on hand the following changes are necessary in order to be able to work 120 tons per day: (*a*) The diffusion cells should be made twice as large as they now are; that is, of 130 cubic feet capacity. (*b*) The opening through which the chips are discharged should be made as nearly as possible of the same area as a horizontal cross-section of the cell. (*c*) The forced feed of the cutters requires a few minor changes in order to prevent choking. (*d*) The apparatus for delivering the chips to the cells should be remodeled so as to dispense with the labor of one man.

(3) The process of carbonatation for the purification of the juice is the only method which will give a limpid juice with a minimum of waste and a maximum of purity.

(4) By a proper combination of diffusion and carbonatation the experiments have demonstrated that fully 95 per cent. of the sugar in the cane can be placed on the market either as dry sugar or molasses.

(5) It is highly important that the Department complete the experiments so successfully inaugurated by making the changes in the machinery mentioned above and by the erection of a complete carbonatation outfit.

Respectfully,

H. W. WILEY, *Chemist.*

The report of 1885 showed such favorable results that in 1886 the House made an appropriation of $94,000, to be used in Louisiana, New Jersey, and Kansas. A new battery and complete carbonatation apparatus were erected at Fort Scott. About $60,000 of the appropriation was expended here in experiments in diffusion and carbonatation.

In his report Dr. Wiley arrived at the following conclusions:

In a general review of the work the most important point suggested is the absolute failure of the experiments to demonstrate the commercial practicability of manufacturing sorghum sugar. The causes of this failure have been pointed out in the preceding pages, and it will only be necessary here to recapitulate them. They were:

(1) Defective machinery for cutting the canes and for elevating and cleaning the chips and for removing the exhausted chips.

(2) The deterioration of the cane due to much of it becoming overripe, but chiefly to the fact that much time would generally elapse after the canes were cut before they reached the diffusion battery. The heavy frost which came the first of October also injured the cane somewhat, but not until ten days or two weeks after it occurred.

(3) The deteriorated cane caused a considerable inversion of the sucrose in the battery, an inversion which was increased by the delay in furnishing chips, thus causing the chips in the battery to remain exposed under pressure for a much longer

time than was necessary. The mean time required for diffusing one cell was twenty-one minutes, three times as long as it should have been.

(4) The process of carbonatation, as employed, secured a maximum yield of sugar, but failed to make a molasses which was marketable. This trouble arose from the small quantity of lime remaining in the filtered juices, causing a blackening of the sirup on concentration, and the failure of the cleaning apparatus to properly prepare the chips for diffusion.

THE PRESENT STATE OF THE INDUSTRY.

The experiments in making sugar from sorghum, which, as above shown, have been in progress for several years at the expense of private capital and the United States Department of Agriculture, have this year reached so favorable results as to place the manufacture of sorghum sugar on the basis of a profitable business.

The success has been due to, first, the almost complete extraction of the sugars from the cane by the diffusion process; second, the prompt and proper treatment of the juice in defecating and evaporating; third, the efficient manner in which the sugar was boiled to grain in the strike-pan. That these results may be duplicated and improved upon will be readily understood from the showing made in Mr. Parkinson's report, and the descriptions of methods and processes used, and the discussion of the same as they appear in the subsequent pages of this paper.

[Abstract of report of W. L. Parkinson.]

To the Board of Directors Parkinson Sugar Company:

GENTLEMEN: I respectfully submit for your consideration the following report of the operations of the works of your company for the season just closing:

It is provided in our contract with the United States Department of Agriculture that certain experiments in sugar-making shall be made by the Department with certain machinery of its own and at its own expense, using the company's plant and machinery. * * *

As you are aware, the crop of cane contracted for last spring was very much less than the capacity of our works to consume. It was considered prudent to limit our danger from loss, by reason of the experimental nature of the work, and at the same time to have sufficient cane to determine thoroughly the value of the work on a practical manufacturing basis. This has been done, though it is now apparent that had the crop been twice as large, the expenses for working it would have been relatively much less. Indeed, a crop double the size of the one just finished could have been worked in about the same time, and at a comparatively trifling additional expense. The plans, methods, and processes which have made the work of the season successful beyond our most sanguine expectations, were adopted early in the season, so that the risks incident to experiments taken into account when contracting for a crop were reduced to the minimum. The fact that at least a portion of these highly successful processes were not tried and adopted last season was no fault of your company, nor of any one connected with this season's work.

To arrive at the cost per ton of cane worked, let us take the working of a single average day, when in full operation, and apart from the cost of experiments referred to.

The capacity of our factory, aside from deficient centrifugals, is limited to the capacity of the diffusion battery. Working twenty-two hours per day, this battery can comfortably handle 135 tons of chips or cleaned cane. This represents a capacity of field cane, or cane with seed tops and blades, of about 170 tons. To handle this, aside from curing and handling seed, cost us per day of twenty-two hours, when running regularly, as follows:

1 weighmaster, at $2	$2.00
1 team, pulling cane onto storage racks, at $2.50	2.50
5 men, unloading and getting cane to cutters, 22 hours, at 12½ cents	13.75
1 man, cutting machine, at 15 cents	3.30
1 man, cleaning machine, at 12½ cents	2.75
1 man, grinder, etc., at 15 cents	3.30
1 man, oiler, at 15 cents	3.30

3 men, diffusion battery, 1 at car and 2 above, at 12½ cents	$8.25
1 man, diffusion battery, director of battery, at 20 cents	4.40
2 men, defecating, at 15 cents	6.60
2 men, double effects, at 15 cents	6.60
1 man, strike-pan, at $5	5.00
1 man, hot room, at 12½ cents	2.75
1 man, barreler, at 12½ cents	2.75
2 men, centrifugals, at 15 cents	6.60
1 man, machinist, at $3	3.00
2 men, engineers, at 20 cents	4.40
5 men, firemen, at 15 cents	10.50
2 men, roustabouts, at 12½ cents	5.50
1 man, water-boy	2.00
1 man, night watch	1.50
2 men, foremen, at $2.50	5.00
Total cost of labor	111.75
Oil, etc	2.50
Coal, 23 tons slack, at 90 cents	20.70
Total	134.75

This makes the cost of working a ton of cleaned cane, with a factory of the capacity of ours, about $1 per ton for labor and fuel, or 90 cents per ton of field cane. The cost per ton for salaries, insurance, wear and tear, etc., must depend, of course, not only upon the size of the salaries and other general expenses, but the number of tons worked. This plant, rated as above, is capable, in seventy days, of working 9,450 tons of chips, or 11,900 tons of field cane. There is necessarily considerable expense in preparing for the season's work, and again in closing up. Allowing liberally for this and for the proper management and control of the works, we may still bring our total expenses, outside the cost of labor and fuel, at $1 per ton upon the above basis. Add to this the cost of labor and fuel, and we have $2 per ton as the total cost per ton of working cleaned cane. These figures are fully verified by our pay-rolls, coal bills, and other expenses while working to our capacity during the season, separated from expenditures in the completion and changing of machinery directly connected with experiments made. And to work a factory with a capacity at least one-half greater than this one would require very little additional expense except in the matter of fuel, and that would be relatively less. It seems to me a very conservative basis, with a factory of the capacity of ours, to place the actual cost of manufacture at $2 per ton of cane; and with such a factory as I have indicated, and with a season of, say, seventy days, it is safe to place the cost of manufacture at considerably less than that sum. It requires but little figuring upon this basis, and with the cost of cane at $2 per ton, and the yield of cane and product secured this year, to show that we have here developed a business of great interest and profit to our State and nation.

To run a factory at the maximum profit it must be operated constantly during the working season. The loss this season by reason of the irregular operation of the factory for want of sufficient cane was very considerable. During the whole season the factory was operated but three whole days of twenty-two hours each. Some idea of the loss from this source may be gathered from the fact that not less than 2 tons of chips were lost at each break in the operation of the diffusion battery. Sixty-five such breaks or stoppages were made while running for sugar. With a larger crop of cane and better arrangements for delivery upon the part of the larger contractors, but little or no difficulty from this source need be apprehended in the future.

	Tons.
Total cane bought	3,840
Total seed tops bought	437
Total field cane	4,277

This represents the crop, less about 30 tons of seed tops yet to come in, from about 450 acres of land. There were something over 500 acres planted. Some of it failed to come at all, some "fell upon the rocky places, where they had not much earth, and when the sun was risen they were scorched;" so that, as nearly as we can estimate, about 450 acres of cane were actually harvested and delivered at the works. This would make the average yield of cane 9½ tons per acre, or $19 per acre in dollars and cents. * * *

Of the total cane worked, 162 tons were consumed in experiments with our cutters and cleaning machinery before the cane was ripe enough for use for either sirup or sugar. No product whatever, not even seed, was saved from this, nor from 10 tons additional brought in since the factory closed down. About 300 tons of mostly down and inferior cane was worked in the early part of the season on the crushers, and without diffusion. The only product from this was molasses, and of that but a small quantity. About 375 tons were also worked for molasses only on the diffusion battery. This, with the exception of 50 tons at the close of the season, and which came in too irregularly to be worked for sugar, was worked before the sugar season began, and comprised such down patches and poorer quality of cane as could be gathered, mainly on the lands belonging to the company. It was an open question whether very poor cane could be worked successfully, even for sirups, on a diffusion battery. Nothing in this direction had hitherto been attempted. The total yield of molasses from this source, and from which no sugar has been taken, is 4,157 gallons. From this are sold 3,157 gallons, for $726.71 net. The remaining 1,000 gallons are still on hand, and are worth 25 cents per gallon.

	Tons.
Deducting from total tonnage, less seed	3,840
Amount not worked for sugar	897
We have total cane and leaves for sugar	2,943

The total number of diffusion cells worked for sugar is 2,643. The weight of a cell of chips is 1,975 pounds. With this as a basis there was worked by diffusion for sugar 2,610 tons of clean cane as it entered the cells. Deducting this from 2,943 tons of cane, with leaves and blades, and we have 333 tons of leaves and blades. The latter are to us a dead loss. A small portion has been hauled away by farmers for feed, but the bulk of this large tonnage is now fit only for manure. This waste was considerably increased by the failure of our separating machines, especially in the early part of the season, to properly discharge their duties. This whole subject was new; machines had to be devised, and their adjustment, which is not yet perfect, caused considerable loss of cane. The weight of blades and leaves will not be far from 10 per cent. of field cane. For either feed or fuel, especially where the latter is much of an object, the blades can be utilized so as to at least cover their own cost. At present we figure the loss from this source to seed account.

SEED.

There have been delivered of seed tops 437 tons. As nearly as we can estimate, there are yet to be delivered 30 tons, making in all 467 tons. From the best calculations we can make, and judging from our experience in former years, seed yields about 70 per cent. of the weight of heads, as bought in over the scales, in cleaned seed. Putting it at 60 per cent., and with 56 pounds to the bushel, we shall have 10,000 bushels of cleaned seed. A portion of this, estimated at 1,000 bushels, has, at considerable additional expense, been picked over by hand, head by head, tied into small bundles, and hung up in the dry. This has been done to provide ourselves with pure seed of the different varieties for planting, and to supply a probable want in the same direction from others. For this hand-picked seed we expect to get not less than $2 per bushel. The cost of handling the seed has not been kept separate from the cost of running the factory. The total cost of curing, stacking, and hand-picking will not be far from $700, fully $200 of which has been expended in securing pure and perfectly cured seed for ourselves and others willing to pay the extra price. To thrash and prepare the seed for market the seed will cost about 6 cents per bushel additional. I estimate that we shall get for our seed crop $7,000 net. There will be left of seed tops, after thrashing, fully 100 tons. These are good for feed or fuel.

SIRUPS.

The bulk of our sirups are stored in the large cistern or cellar under the warehouse. The amount on hand we estimate at 50,000 gallons. This includes the whole crop, except the 3,157 gallons sold in early part of season. Of this we have sold, to be delivered within thirty days, and one car-load of which has already gone, 250 barrels, or about 12,500 gallons, at a price that will net us here 20 cents. This sale includes the bulk of our poorest sirups. I think we can safely estimate our sirup product, exclusive of packages, at $10,000. Considering the condition of our factory for work in cold weather, and the limited capacity of our centrifugal machinery, I recommend their sale, without boiling for seconds.

*   *   *   *   *   *   *

W. L. PARKINSON.

OUTLINE OF THE PROCESSES OF SUGAR-MAKING.

As now developed, the processes of making sugar from sorghum are as follows:

(1) The topped cane is delivered at the factory by the farmers who grow it.

(2) The cane is cut by a machine into pieces about 1¼ inches long.

(3) The leaves and sheaths are separated from the cut cane by fanning mills.

(4) The cleaned cane is cut into fine bits called chips.

(5) The chips are placed in iron tanks, and the sugar "diffused"—soaked out with hot water.

(6) The juice obtained by diffusion has its acids nearly or quite neutralized with milk of lime, and is heated and skimmed.

(7) The defecated or clarified juice is boiled to a semi-sirup in vacuum pans.

(8) The semi-sirup is boiled "to grain" in a high vacuum in the strike-pan.

(9) The mixture of sugar and molasses from the strike-pan is passed through a mixing machine into centrifugal machines, which throw out the molasses and and retain the sugar.

DETAILS OF THE PROCESSES OF SUGAR-MAKING.

An account of the processes of sugar-making ought, doubtless, to begin with the planting and cultivation, growth, and ripening of the cane, for it is here that the sugar is made. No known processes of science or art, save those of plant growth, produce the peculiar combination of carbon with the elements of water which we call sugar. Not only is this true, but the chemist utterly fails in every attempt to so modify existing similar combinations of these elements as to produce cane sugar. It will be interesting here to note three substances of nearly the same composition, viz, starch, sucrose or cane sugar, and glucose or grape sugar. Their compositions are much alike, and may be stated as follows:

	Carbon.	Water.
Starch*	12	10
Cane sugar	12	11
Grape sugar	12	12

* The chemical formulas for these compounds are: Starch, $C_6H_{10}O_5$; cane sugar, $C_{12}H_{22}O_{11}$; grape sugar, $C_6H_{12}O_6$; in which C represents an equivalent of carbon, H of hydrogen, and O of oxygen, or H_2O an equivalent of water.

The chemist produces glucose, or grape sugar, from either starch or sugar by treatment with acid, but all attempts have failed to produce cane sugar from either starch or grape sugar.

THE FARMER THE REAL SUGAR-MAKER.

The farmer, then, or perhaps more accurately the power which impels the plant to select and combine in proper form and proportions the three elements, carbon, hydrogen, and oxygen, is the real sugar-maker. All after processes are merely devices for separating the sugar from the other substances with which it grows.

HOW IS THE SUGAR FORMED IN THE CANE?

The process of the formation of sugar in the cane is not fully determined; but analyses of canes made at different stages of growth show that the sap of growing cane contains a soluble substance having a composition and giving reaction similar to starch. As maturity approaches, grape sugar is also found in the juice. A further advance towards maturity discloses cane sugar with the other substances, and at full maturity perfect canes contain much cane sugar and little grape sugar and starchy matter.

In sweet fruits the change from grape sugar to cane sugar does not take place, or takes place but sparingly. The grape sugar is very sweet, however.

INVERSION OR CHANGE OF CANE SUGAR INTO GRAPE SUGAR.

Cane sugar, called also sucrose or crystallizable sugar, when in dilute solution, is changed very readily into grape sugar or glucose, a substance which is much more difficult than cane sugar to crystallize. This change, called inversion, takes place in overripe canes; it sets in very soon after cutting in any cane during warm weather; it occurs in cane which has been injured by blowing down or by insects or by frost, and it probably occurs in cane which takes a second growth after nearly or quite reaching maturity.

Inversion will be further considered in another place.

THE FARMER'S PART MOST IMPORTANT OF ALL.

Since sugar is produced only by nature's processes of growth and is easily lost through inversion, it is evident that the farmer's part in the process of sugar-making is first and most important of all. It is a subject which invites most careful, scientific, and practical attention, and will be further considered under the subject "Improving the cane."

It is apparent from what has already been said that to insure a successful outcome from the operations of the factory the cane must be so planted, cultivated, and matured as to make the sugar in its juice; that it must be delivered to the factory very soon after cutting; and that it must be taken care of before the season of heavy frosts.

THE WORK AT THE FACTORY.

THE FIRST CUTTING.

The operations of the factory are illustrated in the large drawing, to which the reader is referred in tracing the successive steps. The first cutting is accomplished in the ensilage or feed-cutter. This cutter is provided with three knives, fastened to the three spokes of a cast-iron wheel, which makes about 250 revolutions per minute, carrying the knives with a shearing motion past a dead knife. By a forced feed the cane is so fed as to be cut into pieces about $1\frac{1}{4}$ inches long. This cutting frees the leaves and nearly the entire sheaths from the pieces of cane. By a suitable elevator the pieces of cane, leaves, and sheaths are carried to the second floor.

THE CLEANING.

The elevator empties into a hopper, below which a series of four or five fans is arranged one below the other. By passing down

through these fans the cane is separated from the lighter leaves much as grain is separated from chaff. The leaves are blown away, and finally taken from the building by an exhaust fan. This separation of the leaves and other refuse is essential to the success of the sugar-making, for in them the largest part of the coloring and other deleterious matters are contained. If carried into the diffusion battery these matters are extracted (see reports of Chemical Division, U. S. Department of Agriculture), and go into the juice with the sugar. As already stated, the process of manufacturing sugar is essentially one of separation. The mechanical elimination of these deleterious substances at the outset at once obviates the necessity of separating them later and by more difficult methods, and relieves the juice of their harmful influences. From the fans the pieces of cane are delivered by a screw carrier to an elevator, which discharges into

THE FINAL CUTTING-MACHINE

on the third floor. This machine consists of an 8-inch cast-iron cylinder with knives like those of a planing-machine. It is really three cylinders placed end to end on the same shaft, making the entire length 18 inches. The knives are inserted in slots and held in place with set-screws. The cylinder revolves at the rate of about 1,200 per minute, carrying the knives past an iron dead knife, which is set so close that no cane can pass without being cut into fine chips.* From this cutter the chips of cane are taken by an elevator and a conveyor to the cells of the diffusion battery. The conveyor passes above and at one side of the battery, and is provided with an opening and a spout opposite each cell of the battery. The openings are closed at pleasure by a slide. A movable spout completes the connection with any cell which it is desired to fill with chips.

WHAT IS DIFFUSION?

The condition in which the sugars and other soluble substances exist in the cane is that of solution in water. This sweetish liquid is contained, like the juices of plants generally, in cells. The walls of these cells are porous. It has long been known that if a solution of sugar in water be placed in a porous or membranous sack and the sack placed in water, an action called osmose takes place, whereby the water from the outside and the sugar solution from the inside of the sack each pass through until the liquids on the two sides of the membrane are equally sweet. Other substances soluble in water behave similarly, but sugar and other readily crystallizable substances pass through much more readily than uncrystallizable or difficultly crystallizable bodies. To apply this property to the extraction of sugar the cane is first cut into fine chips, as already described, and put into the diffusion cells, where water is applied and the sugar is displaced.

WHAT HAS TAKEN PLACE IN THE DIFFUSION CELLS.

For the purpose of illustration, let us assume that when a cell has been filled with chips just as much water is passed into the cell as there was juice in the chips. The process of osmose or diffusion sets in, and in a few minutes there is as much sugar in the liquid outside of the cane cells as in the juice in these cane cells; *i. e.*, the water and the juice have divided the sugar, each taking half. Again, assume that as much liquid can be drawn from one as there was water

*This machine is the device of Mr. H. A. Hughes.

added. It is plain that if the osmotic action is complete the liquid drawn off will be half as sweet as cane juice. It has now reached fresh chips in two, and again equalization takes place. Half of the sugar from one was brought into two, so that it now contains $1\frac{1}{2}$ portions of sugar, dissolved in 2 portions of liquid, or the liquid has risen to $\frac{3}{4}$ of the strength of cane juice. This liquid having $\frac{3}{4}$ strength passes to three, and we have in three $1\frac{3}{4}$ portions of liquid, or after the action has taken place the liquid in three is $\frac{7}{8}$ strength. One portion of this liquid passes to four, and we have $1\frac{7}{8}$ portions of sugar in 2 portions of liquid, or the liquid becomes $\frac{15}{16}$ strength. One portion of this liquid passes to five, and we have in five $1\frac{15}{16}$ portions of sugar in 2 portions of liquid, or the liquid is $\frac{31}{32}$ strength. It is now called *juice*, and is drawn off and subjected to the processes of the subsequent operations of the factory. From this time forward a cell is drawn for every one filled.

a	1	2	3	4	5	6	7	8	9	10	11	12
1	w											
2	w	l										
3	w	l	l									
4	w	l	l	l								
5	w	l	l	l	l							
6	w	l	l	l	l	j						
7	w	l	l	l	l	l	j					
8	w	l	l	l	l	l	l	j				
9	w	l	l	l	l	l	l	l	j			
10		w	l	l	l	l	l	l	l	j		
11			w	l	l	l	l	l	l	l	j	
12				w	l	l	l	l	l	l	l	j
13	j				w	l	l	l	l	l	l	l
14	l	j				w	l	l	l	l	l	l
15	l	l	j				w	l	l	l	l	l
16	l	l	l	j				w	l	l	l	l
17	l	l	l	l	j				w	l	l	l
18	l	l	l	l	l	j				w	l	l
19	l	l	l	l	l	l	j				w	l
20	l	l	l	l	l	l	l	j				w
21	w	l	l	l	l	l	l	l	j			
22		w	l	l	l	l	l	l	l	j		
23			w	l	l	l	l	l	l	l	j	
24				w	l	l	l	l	l	l	l	j
25	j				w	l	l	l	l	l	l	l
26	l	j				w	l	l	l	l	l	l
27	l	l	j				w	l	l	l	l	l
28	l	l	l	j				w	l	l	l	l
29	l	l	l	l	j				w	l	l	l

Throughout the operation the temperature is kept as near the boiling point as can be done conveniently without danger of filling some of the battery cells with steam. Diffusion takes place more rapidly at high than at low temperatures, and the danger of fermentation, with the consequent loss of sugar, is avoided. The process will be readily understood from the above diagram, in which the columns represent the cells of the battery, the numbers at the left the number of diffusions; *w*, water; *l*, liquid in the cells, or passing through them, and *j*, juice to be drawn.

INVERSION OF SUGAR IN THE DIFFUSION CELLS.

In the experiments at Fort Scott in 1886 much difficulty was experienced on account of inversion of the sugar in the diffusion battery. The report shows that this resulted from the use of soured cane and from delays in the operation of the battery on account of the imperfect working of the cutting and elevating machinery, much of which was then experimental. Under the circumstances, however,

it became a matter of the gravest importance to find a method of preventing this inversion without in any manner interfering with the other processes. On the suggestion of Professor Swenson a portion of freshly precipitated carbonate of lime was placed with the chips in each cell. In the case of soured cane this took up the acid which otherwise produced inversion. In case no harmful acids were present this chalk was entirely inactive. Soured canes are not desirable to work under any circumstances, and should be rejected by the chemist and not allowed to enter the factory. So, also, delays on account of imperfect machinery are disastrous to profitable manufacturing and must be avoided. But for those who desire to experiment with deteriorated canes and untried cutting machines, the addition of the calcium carbonate provides against disastrous results which would otherwise be inevitable.

CLARIFYING OR DEFECATING THE JUICE.

Immediately after it is drawn from the diffusion battery the juice is taken from the measuring tanks into the defecating tanks or pans. These are large, deep vessels, provided with copper steam coils in the bottom for the purpose of heating the juice. Sufficient milk of lime is added here to nearly or quite neutralize the acids in the juice, the test being made with litmus paper. The juice is brought to the boiling point, and as much of the scum is removed as can be taken quickly. The scum is returned to the diffusion cells, and the juice is sent by a pump to the top of the building, where it is boiled and thoroughly skimmed. These skimmings are also returned to the diffusion cells.

This method of disposing of the skimmings was suggested by Mr. Parkinson. It is better than the old plan of throwing them away to decompose and create a strench about the factory. Probably a better method would be to pass these skimmings through some sort of filter, or, perhaps better still, to filter the juice and avoid all skimming. After this last skimming the juice is ready to be boiled down to a thin sirup, in

THE DOUBLE-EFFECT EVAPORATORS.

These consist of two large closed pans provided within with steam pipes of copper, whereby the liquid is heated. They are also connected with each other and with pumps in such a way as to reduce the pressure in the first to about three-fifths and in the second to about one-fifth the normal atmospheric pressure.

The juice boils rapidly in the first at somewhat below the temperature of boiling water, and in the second at a still lower temperature. The exhaust steam from the engines is used for heating the first pan, and the vapor from the boiling juice in the first pan is hot enough to do all the boiling in the second, and is taken into the copper pipes of the second for this purpose. In this way the evaporation is effected without so great expenditure of fuel as is necessary in open pans or in single-effect vacuum pans, and the deleterious influences of long-continued high temperature on the crystallizing powers of the sugar are avoided.

From the double effects the sirup is stored in tanks ready to be taken into the strike-pan, where the sugar is crystallized.

THE FIRST CHANCE TO PAUSE.

At this point the juice has just reached a condition in which it will keep. From the moment the cane is cut in the fields until now every

delay is liable to entail loss of sugar by inversion. After the water is put into the cells of the battery with the chips, the temperature is carefully kept above that at which fermentation takes place most readily, and the danger of inversion is thereby reduced. But with all the precautions known to science up to this point the utmost celerity is necessary to secure the best results. There is here, however, a natural division in the process of sugar-making, which will be further considered under the heading of "auxiliary factories." Any part of the process heretofore described may be learned in a few days by workmen of intelligence and observation who will give careful attention to their respective duties.

BOILING THE SIRUP TO GRAIN THE SUGAR.

This operation is the next in course, and is performed in what is known at the sugar factory as the strike-pan, a large air-tight vessel from which the air and vapor are almost exhausted by means of a suitable pump and condensing apparatus. As is the case with the saccharine juices of other plants, the sugar from sorghum crystallizes most readily at medium temperature. There are two ways of proceeding.. The simplest is to boil the sirup in the vacuum pan until it has reached about the density at which crystallization begins, then draw it off into suitable vessels and set it away in a hot room (about 110° to 120° F.) to crystallize slowly. The proper density is usually judged by the boiler, by observing the length to which a sample of the hot liquid from the pan can be drawn. This is called the "string-proof" test. A far better method is to "boil to grain" in the pan. This is better because it gives the operator control of the size of the grain within certain limits, because it gives a better appearing sugar, and more important still, because with proper skill it gives a better yield. Several descriptions of this delicate operation have been published. After reading some of the best of these, the writer found, on attempting to boil to grain, that more definite instruction was necessary; and after obtaining the instruction it became apparent that while almost any one can learn to "boil to grain," yet to obtain the best yield requires personal skill and powers of observation and comparison which will be obtained in widely different degrees by different persons. To become a good sugar-boiler one must be an enthusiastic specialist. The Department of Agriculture was fortunate in securing for this important work the services of Mr. Frederick Hinze, a native of Hanover, Germany, and a graduate of the "Sugar Industry School" at Braunschweig.

The process of boiling to grain may be described as follows: A portion of the sirup is taken into the pan and boiled rapidly *in vacuo* to the crystallizing density. If in a sirup the molecules of sugar are brought sufficiently near to each other through concentration—the removal of the dissolving liquid—these molecules attract each other so strongly as to overcome the separating power of the solvent, and they unite to form crystals. Sugar is much more soluble at high than at low temperatures, the heat acting in this as in almost all cases as a repulsive force among the molecules. It is therefore necessary to maintain a high vacuum in order to boil at a low pressure in boiling to grain. When the proper density is reached the crystals sometimes fail to appear, and a fresh portion of cold sirup is allowed to enter the pan. This must not be sufficient in amount to reduce the density of the contents of the pan below that at which

crystallization may take place. This cold sirup causes a sudden though slight reduction of temperature, which may so reduce the repulsive forces as to allow the attraction among the molecules to prevail, resulting in the inception of crystallization. To discover this requires the keenest observation. When beginning to form, the crystals are too minute to show either form or size, even when viewed through a strong magnifying glass. There is to be seen simply a very delicate cloud. The inexperienced observer would entirely overlook this cloud, his attention probably being directed to some curious globular and annular objects, which I have nowhere seen explained. Very soon after the sample from the pan is placed upon glass for observation the surface becomes cooled and somewhat hardened. As the cooling proceeds below the surface contraction ensues, and consequently a wrinkling of the surface, causing a shimmer of the light in a very attractive manner. This, too, is likely to attract more attention than the delicate, thin cloud of crystals, and may be even confounded with the reflection and refraction of light, by which alone the minute crystals are determined. The practical operator learns to disregard all other attractions, and to look for the cloud and its peculiarities. When the contents of the pan have again reached the proper density another portion of sirup is added. The sugar which this contains is attracted to the crystals already formed, and goes to enlarge these rather than to form new crystals, provided the first are sufficiently numerous to receive the sugar as rapidly as it can crystallize.

The contents of the pan are repeatedly brought to the proper density, and fresh sirup added, as above described, until the desired size of grain is obtained, or until the pan is full. Good management should bring about these two conditions at the same time. If a sufficient number of crystals has not been started at the beginning of the operation to receive the sugar from the sirup added, a fresh crop of crystals will be started at such time as the crystallization becomes too rapid to be accommodated on the surfaces of the grain already formed. The older and larger crystals grow more rapidly, by reason of their greater attractive force, than the newer and smaller ones on succeeding additions of sirup, so that the disparity in size will increase as the work proceeds. This condition is by all means to be avoided, since it entails serious difficulties on the process of separating the sugar from the molasses. In case this second crop of crystals, called "false grain" or "mush sugar," has appeared, the sugar-boiler must act upon his judgment, guided by his experience, as to what is to be done. He may take enough thin sirup into the pan to dissolve all of the crystals, and begin again, or, if very skillful, he may so force the growth of the false grain as to bring it up to a size that can be worked.

No attempt will be made here to describe the methods of "boiling for yield," nor to point out the methods by which many special difficulties are to be overcome. Not only does the limited experience of the writer make him hesitate to enter upon these intricate subjects, but their discussion would unduly extend this report. It may be remarked that the handling of the cane, the treatment of the juice, and the preparation of the sirup, have much to do with the difficulties and success of this, the most intricate of all.

THE FINAL SEPARATION OF THE SUGAR FROM THE MOLASSES.

The completion of the work in the strike-pan leaves the sugar mixed with molasses. The mixture is called *melada* or *masse cuite*. It may

be drawn off into iron sugar wagons and set in the hot room above mentioned, in which case still more of the sugar which remains in the uncrystallized state generally joins the crystals, somewhat increasing the yield of "first sugar." At the proper time these sugar wagons are emptied into a mixing machine, where the mass is brought to a uniform consistency. If the sugar wagons are not used, the strike-pan is emptied directly into the mixer.

THE CENTRIFUGAL MACHINES.

From the mixer the melada is drawn into the centrifugal machines. These consist, first, of an iron case resembling in form the husk of mill-stones. A spout at the bottom of the husk connects with a molasses tank. Within this husk is placed a metallic vessel with perforated sides. This vessel is either mounted or hung on a vertical axis, and is lined with wire cloth. Having taken a proper portion of the melada into the centrifugal, the operator starts it to revolving, and by means of a friction clutch makes such connection with the engine as gives it about 1,500 revolutions a minute. The centrifugal force developed drives the liquid molasses through the meshes of the wire cloth, and out against the husk, from which it flows off into a tank. The sugar, being solid, is retained by the wire cloth. If there is in the melada the "false grain" already mentioned, it passes into the meshes of the wire cloth, and prevents the passage of the molasses. After the molasses has been nearly all thrown out, a small quantity of water is sprayed over the sugar while the centrifugal is in motion. This is forced through the sugar, and carries with it much of the molasses which would otherwise adhere to the sugar, and discolor it. If the sugar is to be refined, this washing with water is omitted. When the sugar has been sufficiently dried, the machine is stopped, the sugar taken out, and put into barrels for market.

Simple as the operation of the centrifugals is, the direction of the sugar-boiler as to the special treatment of each strike is necessary, since he, better than any one else, knows what difficulties are to be expected on account of the condition in which the melada left the strike-pan.

CAPACITY OF THE SUGAR FACTORY.

It has already been shown that the operation of the diffusion battery should be continuous. The experience so far had in diffusing sorghum indicates eight minutes as the proper time for filling a cell; or one cell should be filled and another emptied every eight minutes. This, with a battery of 12 cells, 9 of which are under pressure, gives seventy-two minutes as the time during which the chips are subject to the action of the water. If the chips are cut sufficiently fine, the time may be reduced to seven or even to six minutes to the cell without probable loss from poor extraction. The time may be extended to ten minutes per cell without danger of damage when working sound canes.

Taking eight minutes as the mean, we shall have 180 as the number of cells diffused in a day. To secure the best results, all other parts of the factory must be adjusted to work as rapidly as the diffusion battery, so that the capacity of the battery will determine the capacity of the factory.

A plant having a battery like that at Fort Scott, in which the cells are each capable of containing a ton of cane chips, should then have a capacity of 180 tons of cleaned cane, or 200 tons of cane with

leaves, or 240 tons of cane as it grows in the field, per day of twenty-four hours. Those who have given most attention to the subject think that a battery composed of 1½-ton cells may be operated quite as successfully as a battery of 1-ton cells. Such a battery would have a capacity of 360 tons of field cane per day.

THE CUTTING AND CLEANING APPARATUS.

This consists of modifications of appliances which have long been used for other purposes. Simple as it is, and presenting only mechanical problems, the cutting, cleaning, and elevating apparatus is likely to be the source of more delays and perplexities in the operation of the sugar factory than any other part.

The diffusion battery in good hands works perfectly; the clarification of the juice causes no delays; the concentration to the condition of semi-sirup may be readily, rapidly, and surely effected in apparatus which has been brought to great perfection by long experience, and in many forms; the work at the strike-pan requires only to be placed in the hands of an expert; the mixer never fails to do its duty. There are various forms of centrifugal machines on the market, some of which are nearly perfect. If, then, the mechanical work of delivering, cutting, cleaning, and elevating the cane can be accomplished with regularity and rapidity, the operation of a well-adjusted sugar factory should proceed without interruption or delay from Monday morning to Saturday night.

The machines used at Fort Scott for these purposes have not been described in detail. They need only to be made stronger and simpler. Their general plan is not far from that which is likely to be in general use in the near future.

The methods of handling cane need some modifications as to details. The arrangement for making the factory engine unload the cane from the farmers' wagons will probably never be abandoned, since it is much more rapid and leaves the cane in better shape than it can be left by hand.

THE SCIENTIFIC WORK.

The present favorable condition of the sorghum-sugar industry, like the immense development of the beet-sugar industry of Europe, is indebted for its existence largely to long-continued scientific work; and while much of the scientific manipulation which it was once feared would be necessary to success has been eliminated in practice, yet the scientist has not been able to so far simplify the subject as to enable the manufacturer to dispense with his services. I shall try here to make a plain statement of the scientific work necessary in a sugar factory under developments so far made.

WHERE THE SCIENTIFIC WORK IS NEEDED.

It has already been shown that it is only on reaching maturity that sorghum is a profitable sugar plant. To determine when most farm products are ripe is a simple matter of inspection. But it is astonishing to note how greatly different will be the views of, say, a dozen practical farmers as to when a given field of wheat is ripe. Experience in judging of the ripeness of sorghum is far less extended than in the case of wheat. Indeed, the varying conditions of the weather so greatly affect the appearance of ripeness, *i. e.*, the hardness of the

seed, the condition of the leaves, etc., that the manufacturer, who must know before he uses cane whether it is ripe or green, is left no other than the test of chemical analysis. This determines the one point of interest to him, namely, whether the cane has reached such a degree of maturity as to have made its sugar.

Again, although the cane may have reached full maturity, if it shall have been cut and exposed to the atmospheric influences of the earlier part of the season for any considerable time, the sugar may have been changed to glucose. In moist weather this change may take place without any accompanying change in the appearance of the cane. A notable instance illustrating this kind of depreciation occurred at the Parkinson works during the season just closed. A farmer brought in a sample of excellent-looking cane. The book-keeper, who has had considerable experience about sugar factories, examined it, and after ascertaining by the hydrometer that the juice contained about 13 per cent. of dissolved solids, was about to direct the farmer to bring in the cane. An analysis showed that about 8 of this 13 per cent. was glucose, 3 per cent. sugar, and 2 per cent. other substances not more valuable than glucose. Inquiry disclosed the fact that the cane had been cut for three days. The weather had been moist, so that no change in appearance had taken place. To have worked such cane for sugar would have been worse than useless, since the glucose and other substances its juice contained would have held from crystallization not only the 3 per cent. of sugar which this cane contained, but a considerable amount more had it been worked with better juice.

Instances might be multiplied to show the perplexities and disappointments which are liable to result unless a most careful supervision be had of the condition of the cane when it enters the factory. Certainly no field of cane should be cut until the development of its sugar has been reached and determined by the best means available.

In the early part of the season, while the weather is warm, all cane cut in the forenoon should be worked the same day, and that cut in the afternoon should be worked by noon the next day. During the cooler weather of the latter part of the season it is not necessary to be quite so prompt. The delays which will be admissible can be determined by analysis of the cane.

Not only is it necessary to know that the cane enters the factory with its sugar intact, but it is important to see that it does not suffer inversion during the process of manufacture. To prevent this all delays must be avoided. The cane must go promptly and regularly through the cutters and cleaners as rapidly as it can be thoroughly diffused. In a pile of cane chips inversion of the sugar very soon begins, and is soon followed, if not accompanied, by acetic fermentation. If acetic or other active acid be present in the diffusion cells it causes rapid inversion of the sugar under the high temperature of the battery. After leaving the battery the treatment of the juice must be prompt to guard against inversion. Indeed, as has been remarked above, every part of the factory in which the work is done until the juice has been reduced to a sirup should be of such a capacity that it can surely do its work at all times as rapidly as the battery can be operated. It is a matter of great importance to the manufacturer to know whether, at any stage of the process, inversion is taking place. To determine this, analysis of the average samples of freshly-cut chips may be compared with analysis of the product at other stages. For example: To determine whether inversion is

taking place in the battery, crush out and analyze the juice from samples of chips as they enter; then analyze samples of the diffusion juice as it comes from the battery. If the relation of sugar to glucose is the same in these analyses it may be concluded that no inversion is taking place. If, however, the proportion of sugar to glucose is smaller in the diffusion juice than in that obtained directly from the chips by crushing, inversion is probably taking place, and its cause must be sought and remedied.

The subsequent processes of manufacture give little occasion for inversion, unless from delay before the juice has been reduced to sirup. The safest plan is to not let it cool until it is ready for the strike-pan. If unavoidable delays lead to a suspicion that inversion may have taken place, the matter may be determined by analysis. Inversion is not the only cause of loss to be guarded against in the battery. As shown by the report of the Chemist of the United States Department of Agriculture, the average extraction of the battery at the Parkinson factory this season was 92.04 per cent. of all the sugars the cane contained. A closer average extraction than 95 per cent. is scarcely to be expected, and an extraction of less than 90 per cent. should be considered inadmissible. Poor extraction may result from overhurrying the battery, from allowing the temperature to run too low, from raising the temperature too high, thereby filling the upper parts of the cells with steam instead of water, or from improper manipulation of the valves, or from failure of the cutting machines to properly prepare the chips. The perfection of the extraction may be determined by analysis of the exhausted chips from the battery, and if not found satisfactory, the cause is of course to be sought out and remedied.

It is desirable for the manufacturer to know how much sugar he is leaving in the molasses, and also how much molasses he is leaving in the sugar; *i. e.*, the purity of the sugar. These points are readily determined by analysis.

WHO CAN DO THIS SCIENTIFIC WORK?

It is doubtless desirable, though not essential, that the superintendent of a sugar factory be also a chemist. The analyses indicated in the above pages are not intricate. To make them all, however, will require considerable time, and whether the superintendent be capable or incapable of making them, he will scarcely be able to spare the time which ought to be devoted to them.

Any of the graduates of our agricultural or other colleges who have taken a good course of chemistry, with laboratory practice, can by a few months' special training in sugar chemistry and practice in sugar analysis become entirely competent to do the work required in the ordinary operation of a factory, under the direction of the superintendent.

THE YIELD OBTAINED AT FORT SCOTT.

The actual yield obtained was 234,607 pounds of first sugar, from 2,501 cells. If, now, the cell be taken as a ton, the yield of first sugar was $234{,}607 \div 2{,}501 = 93.8$ pounds. Enough of the molasses was reboiled for a second crop of crystals, and the sugar separated, to ascertain that 15 to 20 pounds per ton of cane represented could be obtained. Calling it 15, we have for the entire yield $93.8 + 15 = 108.8$ pounds per ton of cleaned cane. This is a larger yield than is ob-

tainable according to the heretofore accepted theory. There is some uncertainty about the weight of a cell, which may account for the discrepancy between the theoretical and the actual results. It is possible, however, that the theory may need reconstruction. In any case the yield actually obtained is most gratifying.

I have made no mention in the above of the exceptionally large yields of some special strikes made during the season. One strike gave 109 pounds of merchantable sugar for each cellful of chips. The seconds from this would doubtless have brought the yield up to 130 pounds. But the general reader and the prospective manufacturer are more interested in average than in special results. It seems safe to assume that a mean of 100 pounds of sugar and 12 gallons of molasses can be made from each ton of cleaned sorghum cane of average richness.

Science suggests several methods for the complete separation of the cane sugar from the grape sugar and the "not sugar," and further experiments in this direction should be the work of the near future. As yet almost nothing has been done towards the development of methods of separating the grape sugar from the not sugar. This subject presents a most inviting field for the chemist.

THE FUTURE OF THE SORGHUM-SUGAR INDUSTRY.

The sorghum-sugar industry now seems to have an assured future. The quantities of sugar and molasses and other valuable products obtained from each ton of the cane and from each acre of land, well renumerate the farmer for his crop and the manufacturer for his investment and the labor and skill required to operate the factory.

An acre of land cultivated in sorghum yields a greater tonnage of valuable products than in any other crop, with the possible exception of hay. Under ordinary methods of cultivation, 10 tons of cleaned cane per acre is somewhat above the average, but the larger varieties often exceed 12, while the small Early Amber sometimes goes below 8 tons per acre. Let $7\frac{1}{2}$ tons of cleaned cane per acre be assumed for the illustration. This corresponds to a gross yield of 10 tons for the farmer, and at $2 per ton gives him $20 per acre for his crop. These $7\frac{1}{2}$ tons of clean cane will yield—

	Pounds.
Sugar	750
Molasses	1,000
Seed	900
Fodder (green leaves)	1,500
Exhausted chips (dried)	1,500
Total	5,650

The first three items, which are as likely to be transported as wheat or corn, aggregate 2,650 pounds per acre.

Sorghum will yield $7\frac{1}{2}$ tons of cleaned cane per acre more surely than corn will yield 30 bushels or wheat 15 bushels per acre.

In the comparison, then, of products which bear transportation, these crops stand as follows:

Sorghum, at $7\frac{1}{2}$ tons, 2,650 pounds per acre.

Corn, at 30 bushels, 1,680 pounds per acre.

Wheat, at 15 bushels, 900 pounds per acre.

The sugar from the sorghum is worth, say, 5 cents per pound; the molasses, $1\frac{3}{4}$ cents per pound; the seed. $\frac{1}{2}$ cent per pound.

The products give market values as follows:

750 pounds sugar, at, say, 5 cents*	$37.50
1,000 pounds molasses, at, say, 1¾ cents*	17.50
900 pounds seed, at, say, ½ cent*	4.50
Total value of sorghum, less fodder	59.50
The corn crop gives 1,680 pounds, at ½ cent	7.40
The wheat crop gives 900 pounds, at 1 cent	9.00

Thus it will be seen that the sorghum yields to the farmer more than twice as much per acre as either of the leading cereals, and as a gross product of agriculture and manufacture on our own soil more than six times as much per acre as is usually realized from either of these standard crops.

LENGTH OF THE SEASON FOR WORKING SORGHUM.

The season for harvesting sorghum is limited to the months during which it may be worked. At present this dates in our southern counties from about the last of July to the middle or last of October, if a proper selection of varieties of cane has been made. Without doubt this season may and will be lengthened. On this point I can do no better than quote from my report to this Department in 1884:

> As shown by the reports of the sugar factories of Kansas for the last two years, the working season is confined almost exclusively to the months of September and October. When the great cost of sugar-works, the expense of keeping them in repair, and the salaries of the specialists are considered the importance of lengthening the working season becomes painfully apparent. That a $100,000 factory should lie idle for ten months every year implies that it must be run at an enormous profit during the two months or fail to pay interest on the investment.
>
> Several plans have been proposed for extending the time during which the works may run. One of these is the development of earlier varieties of cane by systematic selection of seed, cultivation, and breeding. The researches of modern physiological botanists give reason to hope for good results in this direction.
>
> Another plan proposed is to reduce the juice to a semi-sirup in small auxiliary factories, store the semi-sirup, and make it into sugar during the winter months. This has much to commend it.

CENTRAL AND AUXILIARY FACTORIES—SIZE OF FACTORIES.

The complete sugar factory is an expensive establishment, and while most of the work of operating it can be performed by laboring men of ordinary intelligence, there will be required in each of such factories, whether large or small, at least two men whose attainments will command liberal compensation. These are the chemist, or the superintendent, with a cheaper chemist for an assistant, and the sugar-boiler. Good business management is of course also necessary to success. The chemist and the sugar-boiler can preside over a large as well as over a small factory. Moreover, many of the labors of the factory can be performed with no fewer men in a small than in a large factory. It will therefore be cheaper to work a given amount of cane and to turn out a given amount of product in large than in small factories. The limit, however, beyond which experience so far does not warrant manufacturers to go is believed to be at a capacity of about 270 tons of cleaned cane per day.

*The sugar sold this year at 5¾ cents per pound, the molasses at 20 cents per gallon, and the seed at —— per bushel of 56 pounds. The seed is of about equal value with corn for feeding stock.

In order to use to the best advantage the services of the specialists of the business, it has been proposed to establish at convenient places auxiliary factories which shall carry the processes so far as to prepare sirup for the strike-pan. This sirup will be stored in suitable tanks or cisterns and worked for sugar after the close of the season for handling cane. In this way the working season for the central factory may be prolonged to occupy almost the entire year. The auxiliary factories will cost about half or two-thirds as much as the complete factory, capable of taking care of the same amount of cane. As thus arranged, the central factory will, in addition to its own regular season's work, take care of the sirup from two or three of these sirup factories.

LETTERS PATENT GRANTED TO M. SWENSON.

UNITED STATES DEPARTMENT OF AGRICULTURE,
COMMISSIONER'S OFFICE,
Washington, D. C., December 10, 1887.

SIR: In response to the resolution of the Senate of the 7th instant, directing me to inform the Senate whether any person in the employ of this Department has applied for or obtained a patent on any process connected with certain experiments in the manufacture of sugar from sorghum, conducted under the auspices of the Government, I have the honor to make the following statement of facts:

For the fiscal year 1886-'87 Congress made an appropriation of $94,000 for "continuing and concluding experiments in the manufacture of sugar by the diffusion and saturation process, from sorghum and sugar-cane." By virtue of this appropriation the Commissioner appointed, under date of July 19, 1886, Mr. Magnus Swenson "an agent of this Department to superintend, under the direction of the Chemist, the experiments in the manufacture of sugar from sorghum at Fort Scott, Kans."

In his report to me, under date of December 21, 1886, Professor Wiley, the Chief Chemist of this Department, in detailing the experiments above alluded to, stated that an acidity existed in the diffusion bath, causing a conversion of a portion of sucrose (sugar) into glucose, and that several experiments had been made to correct this acidity. Among those experiments was one in which he added "freshly precipitated carbonate of lime to the extraction bottle," a method which he states was suggested by Professor Swenson. At the close of these experiments, November 15, 1886, Mr. Swenson's service ceased. On April 27, 1887, he was again appointed "superintendent of sugar experiments at Fort Scott, Kans.," which position he now holds. On October 21, 1887, I was informed that Professor Swenson was seeking a patent for the process which he had suggested as above stated, and while in the line of his duty, and which had been tried in a public experiment with the people's money and for the benefit of the country. On that date I filed with the Commissioner of Patents my protest against any action on the part of his office by which Professor Swenson, as an individual, should reap the benefit of this experiment. In answer to that letter I received a communication from the Commissioner of Patents, under date of October 26, stating that Professor Swenson had been allowed letters patent on the process, under date

of October 11, 1887. In that patent the following claims were allowed to Professor Swenson:

(1) As an improvement in the diffusion process of making sugar, the mode herein described of preventing the invertive action of the organic acids in the cane chips upon the sugar during the process of extraction, said mode consisting in adding to the diffusion bath a carbonate of the alkaline earths, substantially as set forth.

(2) As an improvement in the diffusion process of making sugar, the mode herein described of preventing the invertive action of the organic acids in the cane chips upon the sugar during the process of extraction, said mode consisting in adding to the diffusion bath calcium carbonate, substantially as set forth.

The application for this patent was filed on December 29, 1886, after Professor Swenson's employment by the Government had ceased, but the nature of the claims is so closely allied to the experiment made with carbonate of lime, heretofore alluded to, that it seems to leave no doubt that Professor Swenson intended to cover in his patent the suggestion which he made in the line of his duty, which was adopted during his employment, and which amounted only to an improvement in a process which had been conceived, planned, and was then being perfected by the Government of the United States.

I deem it proper to add that I have had an exhaustive search made of judicial decisions and legal opinions bearing upon the validity of a patent granted under these circumstances, and that I have become convinced th t the state of the art, and the fact of Mr. Swenson's appointment and employment by this Department, will affect the validity of his claim, and that I have therefore called the attention of the Attorney-General to all the facts in the case and suggested to him the institution of a suit looking to a perpetual injunction to restrain Professor Swenson from making any use of this patent.

As bearing upon this case, I beg respectfully to inclose, as an appendix to this communication, certain citations and memoranda for the information of the Senate, and in this connection I beg also to recommend such immediate action on the part of the legislative branch of the Government as will enable the Attorney-General, if he has not now sufficient authority, to institute a suit looking to the cancellation of the patent in question.

Very respectfully, your obedient servant,

NORMAN J. COLMAN,
Commissioner of Agriculture.

HON. JOHN J. INGALLS,
President pro tempore United States Senate.

Copy of statement of facts submitted to the Attorney-General for his information by the Commissioner of Agriculture.]

Letters Patent, No. 371528, issued to Magnus Swenson. Manufacture of sugar.

STATEMENT OF FACTS.

The Department of Agriculture directed its attention to the manufacture of sugar from maize and sorghum cane in the year 1877, and since that time has continuously been engaged in investigations and experiments for the purpose of discovering a process that would extract the sugar from these canes in a commercially successful manner. These experiments have been carried on by direct authorization of Congress.

The first session of the Forty-seventh Congress appropriated, "for experiments in the manufacture of sugar from sorghum, beets, and other sugar-producing plants, twenty-five thousand dollars" (Stat. L., vol. 22, p. 91).

The same Congress at its second session appropriated $16,000 (vol. 22, p. 410); the Forty-eighth Congress at its first session appropriated $50,000 (vol. 23, p. 38), and at

its second session, $40,000 (vol. 23, p. 354), for the same purpose. In 1883 the Chemist of the Department conceived the idea of adapting the "diffusion process," successfully used in Europe in the manufacture of beet sugar, to the extraction of sugar from sorghum and maize cane. The results of the experiments carried on in this direction during the year 1883 are contained in special Bulletins Nos. 2 and 3, issued by the Chemical Division of the Department in 1884.

Further investigations were made during the year 1884, and a chemist from the Chemical Division was sent to Europe to study the "diffusion process" as practiced there and the machinery used in its application. The results of the work for this year are fully set out in Bulletin No. 5. Bulletin No. 6 contains a record of the work for the year 1885.

In the fall of 1885 Professor Wiley, Chemist of the Department, was directed to proceed to Europe to study the "diffusion process." Bulletin No. 8 gives the result of his visit there and conclusions reached as to the proper adaptation of process and machinery to manufacture sugar in this country from sorghum cane by the "diffusion process."

As a result of the investigations and experiments brought down to 1886, this Department felt convinced that it had reached a satisfactory solution of sugar manufacture as applied to sorghum, and that it had secured a successful method and devised suitable machinery to establish this work as one of the commercial industries of the country. To test the process and the machinery devised on a commercial scale, and for the purpose of perfecting by experiments any defect that might arise either in the chemical progress of the process or mechanical arrangement of the machinery, the Department received from Congress an appropriation for these purposes.

On June 30, 1886, there was appropriated as follows: "For purchase, erection, transportation, and operation of machinery, and necessary traveling within the United States, and other expenses in continuing and concluding experiments in the manufacture of sugar, by the 'diffusion and saturation processes,' from sorghum and sugar cane, so much thereof as may be necessary, to be immediately available, $94,000" (Stat. L., vol. 23, p. 101).

Under this act of Congress the Commissioner of Agriculture, on the 19th of July, 1886, employed and appointed one Magnus Swenson to "superintend, under the direction of the Chemist, the experiments in the manufacture of sugar from sorghum at Fort Scott, Kans.," at a salary of $2,400 per annum, during the continuance of the experiments. A copy of this appointment is hereto appended (Exhibit A).

The experiments carried on under the foregoing act of Congress last mentioned are set out in detail in Bulletin No. 14, a copy of which is appended (Exhibit B).

In the course of these experiments a difficulty was met with, described on page 28 of Exhibit B, namely, an acidity in the diffusion battery, which caused an inversion of a portion of sucrose into glucose, thereby diminishing the amount of sugar that should be obtained. On the same page are detailed the experiments made to overcome this defect. Experiment No. 4, "the addition of freshly precipitated carbonate of lime to the 'extraction bottle,'" was suggested by Mr. Swenson, the superintendent of the experiments under the foregoing employment. Comments on the result of this experiment will be found on pages 32 and 33 of Bulletin 16.

Experiments at Fort Scott, Kans., were discontinued on November 15, 1886, and the service of Mr. Swenson as agent of this Department ceased on that day.

On December 29, 1886, Mr. Swenson filed an application for letters patent for an improvement in the manufacture of sugar, and on October 11, 1887, letters patent No. 371528 were issued to him.

This patent is for the use of carbonate of lime and carbonates of other alkaline earths in the diffusion bath to prevent the invertive action of organic acids during the process of extraction. It is simply a patent for experiment No. 4, as made at Fort Scott, Kans., by this Department, and set out on page 28 of Bulletin 16.

I am informed that Mr. Swenson is now threatening to prosecute all persons who shall use the method described and covered by his patent, and this Department, still being engaged in experimentation for the manufacture of sugar, will be liable to Mr. Swenson in damages for using a process discovered by itself if the patent aforesaid is rightfully the property of Mr. Swenson.

II.

CONDITION OF THE ART.

The aforesaid patent is for the use of carbonate of the alkaline earths to neutralize organic acids present in saccharine solutions, and thus prevent inversion of sucrose into glucose. This is not new, and has been known to those engaged in the

art of manufacture of sugar for years, and allusions are to be met with to its use in works describing this art, and patents have been issued for this same means for neutralizing acidity in saccharine solutions in England. A brief reference to some of these will be made.

In a work entitled "Sugar Growing and Refining," by Wigner and Harland, published in London in 1882, the following allusions are made pertinent to this part of the art.

On page 185, in describing the diffusion process, it says:

"In order to insure the solidification in the tissues of the soluble substance injurious to the sugar, especially of pectine, which is not coagulated by hot water alone, *lime or some other suitable agent* may be added to the water or liquor."

On page 504 of the same work, in speaking of the alum process, it says:

"After the separation of the alum it is possible to *neutralize* the *acid liquor* with *chalk* (carbonate of lime) only, and this has been done on a large scale for a considerable time. The use of chalk has an advantage over lime in that should an *excess* be added it does no harm to the sirup beyond simply *increasing the insoluble deposit in the filters.*"

A description of the identical advantage claimed by Mr. Swenson in his patent, lines 52 to 58: " * * * it is possible to neutralize the acid liquor with some other alkaline body instead of lime; among other substances which have been tried for this purpose are ammonia, carbonate of ammonia, baryta, carbonate of baryta, strontia, carbonate of strontia, magnesia, carbonate of magnesia." These are the carbonates of alkaline earths mentioned in the patent, lines 58 to 63.

In a pamphlet published in Cincinnati in 1876, entitled "Extraction du Jus Sucré des Plantes sacchariféres, par Diffusion," the author of which is G. Bouscaren, is found, on page 2, a description of the alleged improvement patented by Swenson, and it speaks of the addition of chalk (carbonate of lime) to either the water of the diffusion battery or to the pulp of the cane itself before it goes into the battery.

The following is a translation of the paragraph referred to:

"The solidification of the albumen, pectine, and other elements injurious to the sugar being made in the tissue of the pulp itself by the *addition* of a *proper* quantity of *chalk*, either to the water of alimentation or to the pulp itself before its introduction into the macerators."

Of the English patents that have been issued may be noted the following:

In 1813, No. 3754, to one Howard, the use of alum, lime, and chalk.

In 1874, No. 1736, to Johnson, the use of alkaline carbonates prior to treatment of the sugar with alcohol.

In 1874, No. 1989, to James Duncan, the neutralization of the free acids arising in saccharine solutions by means of carbonate of lime.

III.

From the foregoing statements the following conclusions may be drawn:

(1) That the above patent is held by Mr. Swenson in trust for the use and benefit of the Government and its citizens, the discovery patented having been made by him while specially employed in experimentation, and under an implied contract granting to the Government all property in the results of such experimentation.

(2) That the thing patented was a suggestion made by an employé specially employed for the purpose, and which only amounted to the curing of a defect in a part of a process already planned in its entirety by another, and which of itself was not a complete invention, and which suggestion would belong to the inventor of the process under whom he was working.

(3) The patent is invalid in that the thing patented is not *new*.

Under the first head it is sufficient to say that Congress having authorized the making of these sugar experiments at public expense, they are made for the benefit of the public at large, and the results that spring from them become the property of the Government, to the free use of which all citizens are equally entitled. Persons employed in the carrying on of such experiments, so authorized, by the acceptance of the employment waive all personal right to any discoveries they may make in the course of their employment, and by implication contract that such discoveries shall become the property of the Government. It would be incompatible with the object of the act of Congress authorizing the making of experiments, that any personal property to discoveries made by persons employed under the law should be retained by them, for, if so, then the end had in view, the general benefit of the public, would be destroyed, and public moneys would be expended merely to enable private persons to make discoveries for their own personal use and advantage, and not for the general welfare of the people. Congress would be granting public moneys for private use, and this it can not constitutionally do.

While there are no adjudicated cases bearing upon the right of a person employed by the Government to make experiments to discoveries made by him in the course of experiments, there is a dictum by Justice Field, in the case of the United States *v.* Burns, 12 Wallace, page 246, where he says: "If an officer in the military service, *not especially employed to make experiments with a view to suggested* improvements, devises a valuable improvement, he is entitled to the benefit of it, and to letters patent," etc.

This may be held to imply the *converse*, that where such officer was employed to experiment he would *not* be entitled to patent his improvement.

Under the second head, it is sufficient to state that the suggestion made by Mr. Swenson makes a case on all fours with the general doctrine laid down in the leading case of Agawam *v.* Woolen Company (7 Wallace, 583), on the relations between employers and employés, and that such improvement as he suggested would be for the use and benefit of his employer.

The doctrine is thus stated in the opinion by Justice Clifford:

"Persons employed, as much as employers, are entitled to their own independent inventions, but where the employer has conceived the plan of an invention and is engaged in experiments to perfect it, no suggestions from an *employé*, not amounting to a new method or arrangement, which in itself is a complete invention, is sufficient to deprive the employer of the exclusive property in the perfected improvements. But where the suggestions go to make up a perfect and complete machine, embracing the substance of all that is embodied in the patent subsequently issued to the party to whom the suggestions were made, the patent is invalid, because the real invention or discovery belongs to another," and cases cited.

Under the third head it is unnecessary to comment, for the thing patented not being new, the patent is invalid.

IV.

REMEDY.

The possession by Mr. Swenson of this patent has a serious and damaging effect on the progress of the manufacture of sugar from sorghum cane in this country. It is a cloud on the title of the people of this country to make use of a discovery which the Government has at public expense made. Congress, in authorizing the expending of $225,000 to promote this manufacture, was mindful of its great importance and the benefits to arise from utilizing sorghum cane, which could be grown over an immense area of this country and make valuable thousands of acres of land, and and at the same time cause the production of the home supply of sugar.

This new enterprise has received a damaging blow, and it is desirable that the law department of the Government should take all necessary steps to protect this enterprise, to remove the cloud that to-day prevents the free use of this manufacture as perfected by the Department of Agriculture, and secure to the people the full benefit of all its works.

It is suggested that where a patent has been improperly obtained by a person employed by the Government to carry on experiment for discoveries made in the course of the experiments, the patentee may be *restrained* by injunction from appropriating to his own use any of the rights granted by the patent. This is the view as held by Attorney-General Cushing in an opinion to be found in volume 7, Opinions Attorneys-General, page 656.

EXPERIMENTS AT RIO GRANDE, N. J.

Report of H. A. Hughes.

Sir: I have the honor to present herewith my report, as superintendent of the experiments conducted at Rio Grande the past season, on the manufacture of sugar from sorghum.

The Hughes Sugar House Company is located at Rio Grande, Cape May County, N. J. The building of this company is constructed of brick and iron, 30 feet square, and fully equipped with machinery for extracting and working into merchantable products all of the sugar from 15 tons of cane per day.

The machinery consists of a cleaning and shreding apparatus, a diffusion battery, an open evaporator, vacuum pan, hot room, wagons, and centrifugal.

The cane is cut into sections, freed from leaves, sheaths, and seed tops, and passed in at once to the shreding knives. The leaves and seed tops are also separated and collected into different receptacles. All this machinery is automatic, and the capacity of the cleaning apparatus was proved to be equal to the cleaning of 44 tons in twenty-two hours. It worked without delay or repairs of any description, and the wear and tear was so slight that at the close of the season its condition appeared to be as good as when first started. All this apparatus had been thoroughly tested during the season of 1886.

The shreded cane is packed into perforated baskets and it is then ready for the diffusion battery.

This battery differs radically from those in ordinary use, and was planned in 1886. During this season its work was not perfectly satisfactory, concentration of juice being gained only at a serious loss of sugar in the waste products; but after the close of the season and when the battery was properly managed it was proven and the tests recorded, which have shown that it can extract practically all of the sugar in the cane at an expense for evaporation of 10 per cent. only in excess of that for mill juice; this result is satisfactory, and is believed to be better than that given by any other battery. The diffusion juice from this battery was evaporated in an open pan until one-half of its water was removed; it was then drawn into the vacuum, still further concentrated, grained into the same pan, and struck into sugar wagons in the hot room. The centrifugal machine separated the crude molasses from the raw sugar, leaving it in a condition suitable for refiners' uses. Storage tanks, settling tanks, filter presses, defecators, clarifiers, and chemicals of any kind were not used. The vacuum pan and centrifugal machine do not differ from well-known forms.

THE CROP.

Eighty acres of cane were planted for the use of the mill, and of this 7 acres were grown by neighboring farmers and the balance by the company. Varieties planted were Amber, White African, Kansas Orange, and Late Orange, from which 910 pounds of sugar and 80 gallons of molasses per acre were made. In this account is included the unripe cane used in breaking in the house and all damaged cane. The tonnage far exceeded our greatest expectations. This was occasioned by carefully planting the hills closer and giving it good attention, together with favorable rains. The cost of raising the cane was $11.62 per acre. This includes the hauling out of fertilizers and placing them upon the land, which consisted of 150 pounds muriate of potash per acre, and rotten chips from previous seasons, together with a little stable manure in spots. The cost of potash and chips are not included in the above. The cost of cutting the cane and bringing it to the factory was 45 cents per ton. We paid $3 per day for the use of teams and farm hands, and laborers were paid $1.25 per day.

The average yield was 16½ tons per acre. All the farmers' cane was worked and 27.38 acres of that raised by the company. Over 47 acres were left in the fields. One tract (8.43 acres) averaged 25 tons of cane per acre, from which 1,400 pounds of raw sugar and 120 gallons of molasses per acre were extracted.

Part of the field was used in breaking in the house.

The yields of the farmers' crops varied widely, the maximum being 1,970 pounds of raw sugar and 120 gallons of molasses per acre. This was made from 17 tons and 675 pounds of field cane. The term "field cane" means neither stripped nor topped. The minimum was 540 pounds of sugar and 60 gallons of molasses. All the seed used by the farmers was the same. The variations in yield were caused by the difference in cultivation. Other yields were as follows per acre:

	First.	Second.	Third.	Fourth.
Sugar .... pounds..	1,970	1,560	1,444	1,254
Molasses .... gallons..	120	120	80	116

The company grew this cane on shares, giving the farmers one-half the products, viz, sugar, molasses, and seed. The basis of settlement was for raw sugar 4 cents per pound and molasses at 25 cents per gallon. Consequently the four best acres yielded (reduced to a cash basis) as follows:

	Quantity.	Amount.	Total.
Ephraim Hildrith:			
Sugar, at 4 cents .... pounds..	1,970	$78.80	$108.80
Molasses, at 25 cents .... gallons..	120	30.00	
Joseph Richardson:			
Sugar, at 4 cents .... pounds..	1,560	62.40	92.40
Molasses, at 25 cents .... gallons..	120	30.00	
William Hollingshead:			
Sugar, at 4 cents .... pounds..	1,444	57.76	77.76
Molasses, at 25 cents .... gallons..	80	20.00	
John Brown:			
Sugar, at 4 cents .... pounds..	1,254	50.16	79.16
Molasses, at 25 cents .... gallons..	116	29.00	

This does not include the seed, which has not been thrashed.

WORKING SEASON.

The company commenced breaking in its machinery on September 5 and closed on November 8, making fifty-two days. Twelve days in the commencement of the season were consumed in training men to manage the new machinery. The working season was the most unfavorable since 1880. Frost occurred in the last week in September, but did little damage. Ice one-half inch thick was found on October 15. The crop at that time was growing beautifully and the sugar tests rising rapidly, and the day following this freeze the leaves turned white and died.

At that time we were working on the Kansas Orange fields. This variety did not deteriorate for several days, but at the expiration of this time it gradually declined until October 28, when the purity of the juice was reduced so low that it did not warrant our working any longer for sugar. During this period there were several frosts.

Another effect of the ice on this variety of cane was to make it unable to withstand the repeated heavy gales of wind, which finally blew it down and broke it badly.

It was especially our desire to study the effects of frost on the different varieties, and we were fully aware that we could at any time increase our average sugar per acre by leaving this variety and working the Late Orange. After October 28 we commenced cutting on the Late Orange fields, which had withstood frost and ice in marked contrast with the other cane. This variety stood the freezes and

thaws with very little change, and at the time of the closing of the house it was still up to the average of the season in purity.

The cane was worked after this date at intervals in the diffusion battery until November 22. The cane brought in at this time was frozen solidly, but the juice was in good condition. Warm weather having intervened from the 22d to the 26th, the cane was sampled and tested on November 26 with the intention of making a run for sugar on December 1. Other matters having interfered this was not carried out. There is not the slightest doubt that good sugar crystals could have been obtained until December 1.

This cane has at last been weakened by the unusually severe weather during the past week. It is falling down badly and is only fit for sirup on this date, December 7.

The sugar per acre could have been increased fully 23 per cent. on this season's work by good extraction. It must not be overlooked that the raw sugar made this season would have to be reduced from 20 to 25 per cent. in order to make it chemically pure.

Another source of loss to which I desire to call your attention is in the harvesting of the seed. The seed tops are cut off, spread on the fields to dry, stacked up, and afterwards thrashed. By this method we rarely obtain more than 1½ bushels of seed from a ton of field cane. There is a constant loss in the field during the drying by the seed shelling out and the ravaging of birds. Field mice and rats also attack the stacks. Samples of seed tops carefully saved from these same fields show an average yield, on well-developed canes, of 3 bushels per ton. If this seed could be saved it would be of sufficient value to pay the coal bill for working up the crop in this place.

In making the above statements I wish it to be distinctly understood that neither time nor expense was spared in order to make these records accurate, the house being frequently delayed in order that the records might be secured.

I believe that a ton of field cane is too uncertain a factor to be used as a standard for calculation, as it varies considerably in wet and dry weather. Wagons containing 3,000 pounds of cane, as it comes from the field, will increase to 3,400 pounds and more by being rained on. There is a variation in the weight of the cane before and after frost; also in the percentage of leaves of the large and small canes. For these reasons it is better to use clean chips prepared for the battery or an acre of ground.

It might be worth while to state that this sugar-house, with slight alteration, could be made to work 25 tons per day, having frequently worked at this rate from six to eight hours.

Believing that sorghum-sugar manufacture is to be an established industry and that reports of this nature will have an attraction for the general public, I have written in this simple style and tried to avoid technicalities. Those who wish the details I refer to the reports of your chemists, Messrs. Broadbent and Edson, who, I believe, have faithfully recorded the workings of the house; also to the report of the experimental station of New Jersey, soon to be issued.

Respectfully,

H. A. HUGHES,
Superintendent.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture, Washington, D. C.

NOTE.—For further information concerning the sorghum-sugar industry in New Jersey see Dr. Neale's Bulletin No. 44 of the New Jersey Experiment Station.

SUMMARY OF CHEMICAL WORK AT RIO GRANDE, UNDER DIRECTION OF THE CHEMIST OF THE DEPARTMENT.

[Abstract of report of Hubert Edson.]

The manufacturing season at Rio Grande commenced September 5 and closed November 8. The analyses of juices were begun September 8 and continued throughout the season.

On October 15 there fell a heavy frost, one of the earliest known in Rio Grande, which completely killed all the leaves on the cane and stopped the growth of all the unripe fields. The Late Orange was the only variety which was not seriously injured by the frost and the cold weather following it. This hardy cane, although the frost touched it before it was matured, held its sucrose to the end of the season, even notwithstanding two slight freezes.

It will be noticed from Table III that the extraction of sugar by the battery was very poor. This arose from improper management of the battery by the men employed in the diffusion room, much sugar being thrown out with the exhausted chips from this cause.

EXPERIMENTS IN CRYSTALLIZING SUGARS.

All the sugars as first run from the centrifugal were full of "smear," and after the regular season had closed experiments were made as to the advisability of recrystallizing the sugar, but it was found that the loss in weight was too great to make it profitable, only 8,329 pounds of recrystallized sugars being obtained from nearly double that amount of smear sugar.

In Table VIII are found the analyses of the recrystallized sugars.

On November 19 and 22 experiments were made with the diffusion battery to see if it was possible to obtain a better extraction than the season's work had given.

An extra cell was made and placed outside the battery. Then, instead of emptying one cell of diffusion juice at a time, the two heaviest juices were drawn into the outside cell. By drawing off two cells at a time two baskets of fresh chips could be immersed each time in the outside cell, and the diffusion juice be brought up within 1° Brix of the mill juice, and at the same time an excellent extraction obtained. Both the days in which these experiments were made were very cold. This, of course, made it difficult to keep the battery at a sufficiently high temperature for a proper diffusion.

In the appended table the degree Brix is all that is given, as the juices were not used:

	Chip juice.	Diffusion juice.	Exhausted chip juice.
Average degree Brix:			
November 19	15.50	14.65	1.30
November 22, a. m	13.42	12.66	1.48
November 22, p. m	15.18	13.79	.88

These experiments were conducted by Mr. Hughes and Dr. Neale, chemists of the New Jersey experimental station. The degrees Brix were taken by Dr. Neale and myself.

A sample of chip juice was polarized and found to contain 8.98 per cent. sucrose, with a purity of 59.27.

RESULTS OF ANALYSES.

TABLE 1.—*Analyses of juice from fresh chips.*

Number of analyses	61
	Per cent.
Mean sucrose	8.98
Mean glucose	3.24
Mean total solids (by spindle)	14.02
Sucrose:	
Maximum	12.28
Minimum	4.71

	Per cent.
Glucose:	
Maximum	4.45
Minimum	2.07
Total solids:	
Maximum	17.80
Minimum	10.45

TABLE 2.—*Analyses of diffusion juices.*

Number of analyses	63
	Per cent.
Mean sucrose	6.93
Mean glucose	2.86
Mean total solids (spindle)	11.18
Sucrose:	
Maximum	10.02
Minimum	3.89
Glucose:	
Maximum	3.97
Minimum	1.32
Total solids:	
Maximum	14.40
Minimum	8.38

TABLE 3.—*Sirups.*

Number of analyses	55
	Per cent.
Mean sucrose	18.68
Mean glucose	8.67
Mean total solids (spindle)	32.40
Sucrose:	
Maximum	25.26
Minimum	10.78
Glucose:	
Maximum	15.70
Minimum	3.81
Total solids:	
Maximum	43.16
Minimum	19.88

TABLE 4.—*Exhausted chips.*

Number of analyses	58
	Per cent.
Mean sucrose	2.46
Mean glucose	.98
Mean total solids (spindle)	4.03
Sucrose:	
Maximum	4.23
Minimum	.81
Glucose:	
Maximum	1.62
Minimum	.30
Total solids:	
Maximum	6.64
Minimum	1.33

TABLE 5.—*Masse cuites.*

Number of analyses	6
	Per cent.
Mean sucrose	55.76
Mean glucose	23.44
Mean water	18.50
Mean ash	4.44

TABLE 6.—*Raw sugars.*

Number of analyses	14
	Per cent.
Mean sucrose	73.80
Mean glucose	13.63
Mean water	5.89
Mean ash	2.56

TABLE 7.—*Molasses.*

Number of analyses	14
	Per cent.
Mean sucrose	35.48
Mean glucose	32.20
Mean water	34.72
Mean ash	5.45

TABLE 8.—*Recrystallized sugars.*

Number of analyses	9
	Per cent.
Mean sucrose	90.73
Mean glucose	4.63
Mean water	4.19
Mean ash	.71

(NOTE.—The analyses of *masse cuites* sugars and molasses are only partial. The complete analyses will be given in Bulletin 18.)

ESTIMATES OF COST OF SUGAR FACTORIES, MADE BY MR. H. A. HUGHES.

SMALL CENTRAL SUGAR HOUSE.

Cost and summary of machinery.

One vacuum pan, 4 feet	$850.00
One vacuum pump	500.00
Thirty sugar wagons, at $14	720.00
Two Weston centrifugals, complete, with mixer, at $850	1,700.00
Four tanks, water, sirup, dumps, and extra, at $25	100.00
One 50 horse-power boiler	600.00
One engine, 15 horse power	400.00
Pipe-fittings	800.00
Two boiler feed pumps, at $90	180.00
One water pump	200.00
Two sirup pumps, at $90	180.00
Extra work, machinist, two months, and labor	520.00
Buildings	3,000.00
Freights, lights, and extras	250.00
Total	9,000.00

Capacity of house per day.

Six wagons on 1,080 gallons molasses worked into *masse cuite* for an average, say, 4 pounds sugar to a gallon, or	pounds	4.320
And 45 per cent. sirup	gallons	488
For 260 days, from September 1 to July 1	pounds	1,123,200
For 260 days, from September 1 to July 1	gallons	126,880

Crew, cost of manning, and cost per gallon.

Day shift:	Per day.
One fireman	$1.50
One centrifugal	1.50
One sirup and coopering	2.50
One sugar boiler	3.00

Night shift:	Per day.
One fireman	$1.50
One pan man	1.50
	11.50
Three tons soft coal, at $2.50	7.50
	19.00
Cost per gallon	1.77
Twenty-five gallons for 1 ton field cane ... cents	44¼

SMALL AUXILIARY PLANTATION HOUSE.

One diffusion battery, 50 to 75 tons, complete	$5,600.00
Cutting and cleaning apparatus	800.00
One double effect	2,500.00
Two juice pumps, at $90	180.00
Seven small tanks	100.00
One large tank	25.00
Engine, 8 horse-power	200.00
Boilers, 100 horse-power	1,000.00
Two boiler feed pumps, at $125	250.00
One water pump	250.00
One hot-water pump	125.00
Pipe-fittings	500.00
Building one-story shed	1,000.00
Labor, freight, and incidentals	800.00
Total	13,330.00

Capacity per day.

Lowest estimate, 50 tons field cane; 25 gallons molasses, 45 to 56 per cent. test for each ton field cane worked; 25 gallons for each ton × 50=1,250 per day for eighty days = 100,000 gallons, or 4 acres of ordinary cane per acre for each day; or 320 acres per season of eighty days.

Three such plants would supply 300,000 gallons in a working season.

Crew, cost of manufacture, and cost per ton.

One man throwing cane on carrier	$1.25	
One man on seed topper	1.25	
One man filling baskets	1.25	
One man on eleventh cell	1.25	
One man hanging on baskets	1.25	
One man center	1.25	
One man bagasse	1.25	
One man double effect	1.50	
One man firing	1.50	
One man driving away seed and leaves	1.25	
Total, 10 men	13.00	
One horse on cart	1.00	
	14.00×2 =	$28.00
Labor		28.00
Coal, 5 tons, at $2.50		12.50
		40.50

Or 80.1 cents per ton for labor, etc.

RECAPITULATION.

Capital invested, small central house	$9,000
Capital invested, three small auxiliaries, $13,330	39,990
Total	48,990
	Tons.
Amount of cane worked, 150 tons for eighty days	12,000

Product.

12,000 tons, yielding 25 gallons molasses each	gallons..	300,000
300,000 gallons molasses, yielding 4 pounds sugar each	pounds..	1,200,000
And 45 per cent. molasses	gallons..	135,000
1,200,000 pounds, at 4 cents		$48,000
135,000 gallons, at 20 cents		27,000
18,000 bushels seed, at 40 cents		7,200
Total		82.200

Cost of production.

	Cents.
Auxiliary house, per ton	80.01
Central house, per ton	44.25
	124.26
Cost of packages, per ton	30.00
	154.26×12,000 = $18,511

Farmers' half, $41,100 or $3.43 per ton; the company's half, $41,100, less $18,511, $22,589 for interest, insurance, superintendence, etc.

In working 1,000 tons a day there should be ten 100 to 175 ton batteries and a large central house. Auxiliary houses of this size would cost complete about $20,000 each and the central house would cost without bone-black $90,000. There would also be a corresponding reduction in working expenses.

EXPERIMENTS AT LAWRENCE, LA.

CANE-SLICER.

In order to secure a multiple feed for a single cutter it was determined to adopt the horizontal disk system. Cutters of this kind not being made in this country, it was necessary to purchase one in Europe.

The cutter built by the Sangerhauser Company, of Sangerhausen, Germany, was selected. This cutter was guarantied to give from 200 to 250 tons of chips per twenty-four hours, suitable for diffusion.

This slicing machine, having been tried in Demerara in the early summer, proved inefficient. To guard against failure from lack of a proper cutter another machine, which had already proved successful in Java, was ordered from the Sudenburg Company of Magdeburg.

The small cutter with a horizontal disk, tried at Fort Scott last year, was also sent to New York for certain alterations, and thence to Magnolia. Unfortunately the new knives sent with the machine had not been properly tempered, and this prevented the use of this cutter for the preliminary experiments.

Mr. R. Sieg, of New Orleans, who had had large experience in working cane-cutters in Louisiana in 1874 and the following years, was also instructed to build a cutter with vertical disk and multiple feed. We found, however, that the time at his disposal was too short to permit the building of such a machine as he desired.

On October 6 I received the following instructions:

You are hereby instructed to go to Fort Scott, Kans., and after inspecting the work of the Department there in the manufacture of sugar, you will proceed to Lawrence,

La., to conduct the work of the Department at that place in the application of diffusion to the extraction of sugar from sugar-cane.

You are also authorized to travel between Magnolia Station and New Orleans as often as may be necessary to secure the proper conduct of public business.

Very respectfully,

NORMAN J. COLMAN,
Commissioner.

In obedience to the above instructions I reached Magnolia on the evening of October 17, 1887. The experimental work was conducted without being complicated by the use of any process or machinery in which any one in the employment of the Department had any patented or financial interest whatever. The sole object in view was to benefit those engaged in the manufacture of sugar in all parts of the country. Experiments conducted at public expense should, in my opinion, be for the public good, and not for the benefit of a private individual or corporation.

On the morning of the 19th the diffusion building was badly injured by a cyclone. The water-tank to supply the battery, together with the tower supporting it, was blown on to Governor Warmoth's sugar-house, causing great damage. Nearly a month was required to repair the damage and restore the building and apparatus to the condition in which it was before the storm.

The delays incident to the working of new machinery were numerous. The original plan contemplated having all the machinery ready by the 1st of October, thus permitting a series of preliminary trials extending over a month before the regular season began.

Instead of this, however, unavoidable delays, incident to the imperfections of the machinery and the damage of the storm, postponed even the preliminary experiments until the beginning of December.

A recital of the details of these delays would only lengthen the report without adding anything to its value. It must be said, however, in this connection that the gentlemen associated with me worked earnestly and faithfuly through all the discouragements attending the preparation of the machinery.

Mr. Ernest Schulze, representing the Sangerhauser Company, was also present, and rendered valuable assistance in putting his cane-slicer in working order.

The numerous defects in the battery and the cutter having been remedied, the apparatus of the Colwell Company was accepted on December 11, 1887.

Mr. A. W. Colwell, the president of the company, was present during the final trials of the battery, and rendered valuable assistance in putting it into working order. The defects in both cutter and battery were of a minor character, but were such as to greatly delay the use of new machinery for new purposes. The final working of all the machinery was excellent and satisfactory. The season's experiments, however, disclosed many improvements of a seemingly trivial nature, but by the adoption of which a more economical working of the diffusion process can be secured. These improvements will be discussed in another place.

The first results from the experiments were obtained from the run of December 3, 1887.

The juice was treated with .3 per cent. its weight of lime, and after the precipitation of the lime with carbonic dioxide, an amount of lignite equal to 10 per cent. of the weight of the sugar present was added.

The juice filtered readily through the presses, forming firm, hard cakes. The filtered juice was treated with phosphate of soda, 15 pounds of this salt being added for each 5,000 pounds of juice.

The phosphate produced an abundant flocculent precipitate, which filtered easily through the twin filter presses, giving a juice of remarkable limpidity. The *masse cuite*, however, was dark, and the molasses much inferior in color to that made by the use of bone-black and ordinary clarification.

The phosphate of soda did not produce as favorable results as had been expected, and its further use was discontinued.

Following are the data obtained in the first run:

First diffusion run, December 3, 1887.

	Total solids.	Sucrose.	Glucose.
		Per cent.	*Per cent.*
Juice from chips:			
First	15.20	12.01	.96
Second	14.45	11.92	1.00
Third	15.45	12.84	1.02
Average	15.03	12.26	.99
Diffusion juice:			
First	10.88	8.88	.83
Second	10.40	8.65	.74
Average	10.64	8.76	.78
Exhausted chips:			
First sample	....	.51	....
Second sample	....	.76	....
Third sample	....	.91	....
Average	....	.73	....
Carbonated juice	11.09	9.20	.70
Waste water	....	....	.12
Semi-sirup	51.80	42.20	3.39
First sugar	....	97.50	....
Molasses from first sugar	76.30	45.00	11.11
Second sugar	....	91.60	....

Cane used	tons..	80.3
First sugar per ton	pounds..	146.1
Second sugar per ton	do....	40.1
Total first and second sugars		186.2
Third sugar		15
The total sugar in the cane at 90 per cent. juice was	pounds..	220.6
Of this there was obtained 146.1 pounds at 97.50	do....	144.4
And 40.1 pounds at 91.6	do....	36.7
Total pure sucrose obtained	do....	181.1
Left in chips	do....	14.6
Total left in molasses and lost in manufacturing	do....	24.9

(NOTE.—The third sugar will not be dried until in May or June, 1888. The estimates of third sugar have been made by Mr. E. C. Barthelemy.

EXTRACTION.

The percentage of sucrose left in the spent chips was .73. Sucrose in cane was 11.03 per cent. The per cent. of extraction is therefore $11.03 - .73 = 10.30 \div 11.03 \times 100 = 93.4$.

SECOND TRIAL.

Another trial was made of the diffusion machinery beginning December 9. Carbonatation was again used, but without lignite or

any further treatment. The juice passed directly from the filter presses to the double-effect pan.

The quantity of lime employed was .6 per cent. the weight of the juice. The filtration was perfect. The experiment was remarkable in showing that a perfect defecation can be made with carbonatation with a much smaller percentage of lime than had been supposed necessary.

The *masse cuite* was dark, but the sugar a fair yellow.

Following are the data of the run:

Second diffusion run, December 9, 1887.

	Total solids.	Sucrose.	Glucose.
Fresh chips:		*Per cent.*	*Per cent.*
First sample	14.06	11.70	1.04
Second sample	15.65	13.64	.76
Third sample	15.70	13.52	.75
Fourth sample	15.50	13.02	.81
Fifth sample	14.00	11.18	1.02
Average	14.98	12.61	.88
Diffusion juice:			
First sample	9.36	7.83	.67
Second sample	8.67	7.25	.58
Third sample	9.68	7.61	.55
Fourth sample	10.40	8.69	.91
Fifth sample	10.20	8.45	.78
Average	9.66	7.96	.69
Carbonated juice:			
First sample	9.12	7.73	.65
Second sample	8.74	7.35	.57
Third sample	10.20	8.55	.50
Fourth sample	11.40	9.00	.73
Average	9.86	8.16	.61
Exhausted chips:			
First sample	......	1.58	......
Second sample	......	1.69	......
Third sample	......	.48	......
Fourth sample	......	.32	......
Fifth sample	......	.40	......
Average	......	.89	......
Semi-sirup	47.70	38.90	2.96
First sugar	......	96.60	......
Molasses from firsts	72.20	42.40	10.50
Second sugar	......	87.30	......

Yield of first sugar per ton	pounds..	128
Yield of second sugar per ton	do....	43
Cane used	tons..	90
The total sugar in the cane at 90 per cent. juice was, per ton	pounds..	226.98
Of these there was obtained 128 pounds at 96.6	do....	123.6
And 43 pounds at 87.3	do....	37.5
Total pure sucrose obtained, per ton	do....	161.1
Pure sucrose left in chips, per ton	do....	17.8
Pure sucrose left in molasses and lost in manufacture, per ton	do....	41.1
Third sugar estimated, per ton	do....	17
Percentage sugar in cane extracted		92.16

The poor yield was due to use of thick chips during the first part of the run, causing a loss of 1.6 per cent. sucrose in the chips.

THIRD TRIAL.

In this run the use of carbonatation and lignite was discontinued. The diffusion juices were treated with sulphur fumes until well satu-

rated. They were then treated with lime and clarified in the usual way.

The clarification took place readily. The quantity of scums was very small, and the sediment subsided rapidly, forming a thin layer on the bottom of the tank, permitting the clear liquor to be easily and completely drawn off. The juice passed at once from the clarifiers to the double-effect pan and subsequently received no further purification.

Following are the analytical data obtained:

Third diffusion run, December 10 and 11, 1887.

	Total solids.	Sucrose.	Glucose.
Fresh chips:		*Per cent.*	*Per cent.*
First sample	14.39	11.89	.79
Second sample	12.77	10.63	.77
Third sample	14.49	12.06	.80
Average	13.88	11.53	.78
Diffusion juice:			
First sample	9.42	7.82	.62
Second sample	9.41	7.87	.59
Third sample	9.55	7.86	.67
Average	9.46	7.85	.63
Sulphured juice:			
First sample	9.69	8.17	.66
Second sample	9.12	7.53	.58
Average	9.40	7.85	.62
Clarified juice:			
First sample	9.95	8.21	.67
Second sample	9.89	8.06	.63
Third sample	10.32	8.39	.71
Average	10.05	8.22	.67
Exhausted chips:			
First sample	....	.80	....
Second sample	....	.50	....
Third sample	....	.77	....
Fourth sample	....	.93	....
Average	....	.75	....
Semi-sirup	44.70	34.60	2.87
First sugar	....	96.30	....
Molasses from first sugar	72.90	36.70	12.07

First sugar per ton ......pounds..	143
Number tons cane used	110

The molasses from the first sugar was boiled to string proof and put in wagons. A good crystallization of second sugar was secured, but the molasses having been left too acid, a good separation was not secured. Mr. Barthelemy therefore decided to reboil the molasses with some of the product of the mill process, and therefore no statement of the quantity of second sugar can be given. It was estimated at 30 pounds per ton.

The cane from which this run was made was grown on new back land and was the poorest of the whole season.

The percentage of sugar extracted of total sugar in cane was 92.80.

FOURTH TRIAL.

In this run the diffusion juice was treated with lime until almost neutral. It was then boiled, skimmed, and allowed to settle. The

scums and sediments were of small volume and were all returned to the battery.

The juice received no other treatment whatever for clarification. It was converted to sirup in a double-effect vacuum pan. The capacity of this pan was not quite great enough to evaporate the juice as fast as furnished by the battery. For this reason the run, which might have been finished in two days, occupied a part of a third day. The quantity of cane worked was 200 tons.

Following is a record of the analytical data obtained:

Fourth diffusion run, December 29, 30, and 31, 1887.

	Total solids.	Sucrose.	Glucose.
Juices from fresh chips:		*Per cent.*	*Per cent.*
A. M., first day	16.46	14.23	.49
P. M., first day	17.27	15.33	.43
Midnight, first day	17.26	15.12	.43
A. M., second day	17.13	14.84	.45
Midnight, second day	16.97	14.93	.54
A. M., third day	16.19	13.90	.61
P. M., third day	16.26	14.05	.50
Average fresh chip juice for run	16.79	14.60	.49
Diffusion juices:			
First sample, first day	9.72	8.71	.32
Second sample, first day	10.09	9.01	.29
Third sample, first day	11.38	10.16	.30
Fourth sample, first day	11.60	9.31	.53
First sample, second day	11.10	9.87	.32
Second sample, second day	10.92	9.69	.33
Third sample, second day	10.94	9.77	.44
First sample, third day	10.45	9.31	.35
Second sample, third day	10.87	9.69	.38
Average diffusion juice for run	10.78	9.50	.36
Clarified juices:			
Average for first day	10.75	9.34	.32
Average for second day	11.77	10.36	.32
First sample, third day	12.01	10.36	.41
Second sample, third day	11.61	9.78	.38
Third sample, third day	11.25	9.51	.36
Average clarified juice for run	11.48	9.87	.36
Juices from exhausted chips:			
First sample, first day	....	.52	....
Second sample, first day	....	.61	....
Third sample, first day	....	.83	....
First sample, second day	....	1.12	....
Second sample, second day	....	.72	....
Third sample, second day	....	.95	....
First sample, third day	....	1.09	....
Second sample, third day	....	1.30	....
Third sample, third day	....	1.10	....
Average exhausted chip juice for run	....	.91	....
Semi-sirup for first strike	37.37	33.10	.99
Masse cuite first strike	....	81.20	....
First sugar from first strike	....	98.40	....
First molasses from first strike	76.22	51.80	7.76
Semi-sirup for second strike	40.00	35.10	1.19
Masse cuite	....	80.60	....
First sugar	....	98.90	....
Molasses from second strike	79.00	55.60	....
Average extraction	....	93.80	....
Pounds first sugar per ton	....	165.50	....
Per cent. sugar extracted obtained in firsts	....	66.20	......

Second sugar per ton	pounds	45.9
Third sugar per ton (estimated)	do	*18.0
Cane used	tons	200

* On February 29 I was informed by letter from Governor Warmoth that the third sugars from the fourth run had been dried and weighed, yielding 3,723 pounds, or 18.6 pounds per ton.

FIFTH TRIAL.

The fifth and last run of the diffusion battery was begun on January 14 and finished on the 18th. This trial was made after the milling work had been completed. The diffusion juices were treated precisely the same way as the mill juices had been, and after passing over bone-black were concentrated to sirup in a Yaryan quadruple effect, which had been in use with the mill juices during the manufacturing season.

The working of all the machinery during this final trial was admirable, and the even march of the whole work promoted the efficiency of the machinery and the successful manipulation of the juice.

Analytical data of fifth run.

No.	Brix.	Sucrose.	Glucose.
Fresh chips:		*Per cent.*	*Per cent.*
397	16.87	14.23	.74
400	16.39	13.45	.87
403	16.39	13.79	.89
405	17.09	14.73	.68
408	16.86	12.11	.75
411	17.16	14.73	.64
414	16.93	14.06	.70
417	17.00	14.50	.61
420	16.70	13.93	.73
423	16.79	14.11	.74
426	17.19	14.17	.61
429	16.73	14.19	.59
437	17.11	14.55	.61
440	16.17	13.48	.75
443	16.17	13.43	.76
446	16.60	13.99	.63
449	16.63	14.39	.65
452	16.77	14.28	.63
459	16.23	13.29	.77
465	16.03	13.79	.76
468	16.07	13.35	.85
472	16.84	14.34	.64
475	16.37	13.54	.82
478	16.51	14.17	.70
484	16.94	14.38	.65
490	16.57	14.52	.63
Maximum	....	14.73	.89
Minimum	....	12.11	.59
Mean	....	13.98	.70
Diffusion juices:			
398	11.37	9.28	.60
401	10.67	8.66	.64
404	10.61	8.92	.49
409	10.38	8.53	.41
412	11.01	9.10	.45
415	10.91	8.60	.48
418	10.71	8.76	.40
421	10.65	8.77	.40
424	10.57	8.51	.44
427	10.52	8.90	.46
430	10.65	9.05	.32
438	10.27	8.46	.35
441	10.73	8.94	.45
444	10.88	8.99	.42
447	49.50	7.68	.34
Diffusion juices—Continued.		*Per cent.*	*Per cent.*
450	9.88	8.12	.43
453	10.87	9.00	.3[illegible]
460	9.89	....	.45
466	10.67	8.41	.61
469	10.47	8.01	.72
473	10.17	8.02	.48
476	10.15	7.86	.48
479	10.31	7.92	.47
485	10.59	8.26	.52
491	9.69	7.53	.61
Maximum	....	9.28	.72
Minimum	....	7.53	.34
Mean	....	8.41	.47
Exhausted chips:			
399	....	.52	....
402	....	.21	....
407	....	.52	....
410	....	.32	....
413	....	.52	....
416	....	.41	....
419	....	.33	....
422	....	.42	....
425	....	.42	....
428	....	.55	....
431	....	.42	....
439	....	.50	....
442	....	.50	....
445	....	.42	....
448	....	.46	....
451	....	.69	....
454	....	.55	....
461	....	.51	....
467	....	.42	....
470	....	.39	....
474	....	.43	....
477	....	.54	....
480	....	.34	....
486	....	.22	....
492	....	.48	....
Maximum	....	.69	....
Minimum	....	.21	....
Mean	....	.44	....

The molasses from the first sugars being very rich, the method of reboiling to grain was employed. To this end the molasses of the first strike, having been reduced to 55 to 60 per cent. of total solids, was boiled on a nucleus of first sugar left in the pan from the second strike. In this way all the molasses was boiled to grain with most gratifying results except that from the last strike of the first sugars.

The attempt to boil this to grain did not succeed in giving a *masse cuite* which could be dried with ease. The molasses running from

the machines was so thick that it clogged them up. Seven large sugar wagons were filled with this material and set in the hot room.

The sugars made were equal in every respect to those obtained by milling in similar instances. Without counting the second sugar above named, the grained sugar per ton amounted to 181.5 pounds. The grained sugars in wagons will yield not less than 7,500 pounds, or 18 pounds per ton.*

The third sugars are estimated by Mr. Barthelemy at not less than 16 pounds per ton.

The total yield per ton of the fifth run will reach, therefore, 215.5. The number of tons of cane used was 417.

Summary of results.

Number of run.	Cane.	Mean sucrose in juice.	Mean glucose in juice.	Sugar grained in pan per ton. First sugar.
	Tons.	*Per cent.*	*Per cent.*	*Pounds.*
1	80.3	12.26	.99	146.1
2	90.0	12.61	.88	128.0
3	110.0	11.53	.78	143.0
4	200.0	14.60	.49	165.5
5	417.0	13.98	.70	181.5

Wagon sugar per ton.		Total sugars per ton.
Second sugar.	Third sugar (estimated).	
Pounds.	*Pounds.*	*Pounds.*
40.1	15	201.2
43.0	18	189.0
*30.0	12	185.0
45.9	18	229.4
*18.0	16	†215.5

*Estimated.

†Actual weight, 16.3 pounds per ton, and 213.8 pounds total sugars per ton. The third sugars from this run were mixed with molasses from the mill products, and no separate return of it will be made.

COMPARATIVE YIELDS BY MILLING AND DIFFUSION.

The yield in first or grained sugars affords the best comparison of the two systems of manufacture. Judged by this standard the diffusion process had given a yield of sugar fully 30 pounds per ton greater than was afforded by milling. For further data on this point see the report of Governor Warmoth farther on.

CHARACTERISTICS OF DIFFUSION JUICE.

The juice of diffusion differs from the mill juice chiefly in its content of water. In addition to this, also, must be noted a slight increase in the ratio of glucose to sucrose. This is due doubtless to a slight inversion of the sucrose during the process of diffusion. From a commercial point of view the loss is insignificant. Further, it may be said that there appeared to be in the diffusion juice treated in the

* The actual yield reported to me February 23, by Governor Warmoth, was 6,805 pounds, or 16.3 pounds per ton.

ordinary way a slightly increased amount of gummy matter. This was noticed only in filtering the sirup through bone-black. In the strike-pan and the centrifugal the products of diffusion worked fully as well as those from the mill.

DISPOSITION OF CHIPS.

An attempt was made to pass the chips through the five-roll mill, but it was found impracticable. The first rolls would not take them easily, and the second set of rolls had to be opened somewhat to secure the proper feed. The bagasse issuing from the mill contained still 65 per cent. water and made a poor fuel.

It would probably not be a difficult problem to so adjust the mill as to secure a proper drying of the chips. To return the chips to the soil, however, appears to be the most rational method of disposing of them.

It is true that if spread too thickly on the soil the chips may prove highly injurious, but if distributed in a thin layer, covering almost if not quite the original acreage of the cane furnishing them, they would certainly prove advantageous. The chips would not only furnish organic matter to the soil, and thus increase its porosity, but they also contain still a considerable part of nitrogenous matter, which would afford a valuable plant food. Even the richest land should be treated fairly, and the cane-field should receive as nearly as possible as much as it gives. The additional cost of replacing the chips on the field is a matter which should receive attention here, but the benefit will apparently be greater than the expense. During the manufacturing season the chips can be deposited in large beds, which subsequently can be transferred to the field. If time for the partial decay of the chips should be desired, the accumulation of one season need not be moved until the following year.

DISPOSITION OF SCUMS AND SEDIMENTS.

The scums and sediments were successfully treated by the process of carbonatation. The expense of a lime-kiln is not necessary for this work. It was satisfactorily done by drawing the carbonic dioxide gas directly from the stack of the boilers. As high as 11 per cent. of CO_2 was found in the gases from this source.

The scums, etc., treated with 2 to 3 per cent. of lime, are subjected to the action of the gas until the lime is precipitated. They then can be easily and rapidly filtered.

By means of a cheap and convenient *monte jus* the scums and sediments were also returned to the battery. The method of operating was as follows:

The scums and sediments from the clarifiers were collected in a tank furnished with a steam coil to keep them at the boiling temperature. This tank was connected with a *monte jus* of 50 liters capacity. This apparatus was connected with the compressed-air service used in operating the battery. It was so arranged that the master of diffusion, or his assistant, could operate it directly from the central column of the battery.

After each cell was filled with chips, 50 liters of the scums were run into the *monte jus* from the storage tank, and, by means of compressed air, poured into the full cell. The process of diffusion was then continued in the usual way. The quantity of liquid drawn from each cell was increased by the amount of scums added. For instance, if 900 liters were the amount regularly drawn, 950 would be taken from a cell to which the scums had been added, as above indicated.

No deterioration of the diffusion juice could be detected in using this method.

This procedure was also used during the progress of the work conducted by the Department at Fort Scott during the season of 1887. I have been told that a patent has been applied for to cover this process, and have therefore placed on record the experiments made at Lawrence for the public benefit.

THE USE OF LIGNITE.

In order to get lignite of the best possible variety and in the best form for use, a few tons of the ground article were purchased from the inventor of the process of filtering with brown coal, Mr. Fritz Kleeman, of Schönigen, Germany.

I have already alluded to the successful use of lignite in conjunction with lime and carbonic acid.

This experiment, however, did not show that any beneficial effects were produced by the introduction of the lignite.

Afterwards experiments were made by Mr. Kleeman himself, using lignite alone. Mr. Kleeman said the arrangement of the clarifying tanks was not suitable to the process. The filter cloths were soon clogged and the attempt at filtration had to be abandoned.

Later in the season I received a letter from Mr. W. J. Thompson, of Calumet Plantation, in which he said that he would make a trial of the process under more favorable conditions than obtained at Magnolia, and requesting me to send him enough of the Kleeman lignite for that purpose. This I gladly did. Mr. Thompson made a run of nineteen clarifiers with lignite, but found so many difficulties attending the work that its further progress was abandoned.* On the other hand, Professor Stubbs, at Kenner, working with a small press, secured results that were highly satisfactory.

The results of the work with lignite show—

(1) That on a large scale the filtration takes place with great difficulty, unless a very great quantity of the lignite be used and the juice be neutral or slightly alkaline.

(2) That with a slight excess of lime, precipitated with carbonic acid, lignite can be successfully used to increase the filtering surface.

(3) The decolorizing power of lignite varies with the nature of the sample. In some cases this property is present in a high degree; in others, entirely absent.

(4) The successful working of the process on a small scale would indicate that it might be worked commercially.

(5) In juices as pure as those of sugar-canes, filtration through lignite, even if easily done, does not seem to be necessary.

I had expected to have Mr. Thompson's complete report on the experiments with lignite before this time, but it has not yet been received.†

COMPARATIVE YIELD FROM MILL AND DIFFUSION BATTERY.

The comparative yield from the cane-mill and the diffusion battery is given by Governor Warmoth in a paper read before the Planters' Association at the February meeting, viz:

> The first cane worked was from second year stubble, and it gave us 146 pounds of first sugar to the ton and 40 pounds of seconds.

*See Report of Mr. Thompson, *post*.

†Mr. Thompson's report was received March 5.

The molasses was put into the cisterns with the other, and we can not give any estimate of the thirds. Our mill gave us 145 pounds first and second sugars from this cane.

The next test was from some green cane, grown on new land, yielding 28 tons of cane per acre, considerably blown down and sprouted in a small degree. This had much less sugar in it than the first cane. Yet we got 128 pounds of first sugar and 43 pounds second sugar per ton from it.

Our mill gave us 140 pounds of first and second sugar per ton from this cane.

The next run gave us 165.5 pounds firsts, 45.9 of seconds; total, 211.4 pounds, with thirds in the wagons, which we estimate will give us 15 pounds more, a total of 226.4 pounds.

The next run was on 450 tons of cane, beginning on the 13th of January, ending on the 18th. This cane was rich and fine. It had been killed on the 26th of December, was not windrowed, but was in fine condition. From this cane diffusion gave us 181 pounds of first sugar and grained seconds, with enough left in the wagons to bring it up to 223 pounds. From this cane we got 193 pounds of first and second sugar by our mill.*

All of this shows about the same difference between diffusion and our mill-work of about 35 pounds of sugar per ton of cane. I do not mean to be invidious when I say that I think we got a little better extraction by our mill than any of our neighbors. My friend, Mr. Dan Thompson, got more sugar to the ton of cane in 1886 than we did, but this result was obtained not so much by his extraction as by the skillful work in the balance of his house, in which I firmly believe the equal does not exist in Louisiana.

It is safe to say that the average yield per ton of cane in the State is not over 110 pounds. I believe diffusion will bring the average up to within the neighborhood of 200 pounds, a gain of certainly 75 pounds, and perhaps 90 pounds, per ton of cane.

My nearest neighbor, Mr. Bradish Johnson, obtained the past season 136 pounds of sugar per ton of cane. We are within 3 miles of each other; our land is much the same; our cultivation is substantially the same. It is fair to assume his cane was as rich as mine, yet we had about 175 pounds of all sugar per ton, a difference of 39 pounds of sugar per ton on our mill-work, and about 71 pounds difference on the diffusion work. Take his estate for illustration:

His 10,000 tons of cane gave him 1,390,000 pounds of sugar. Had he worked his crop by diffusion he would certainly have had 70 pounds more sugar to the ton of cane. This would have increased his yield 700,000 pounds of sugar, which, at 5½ cents per pound, would have given him $38,500 more for his crop than he received.

Take my own crop of 13,300 tons of cane. Had I worked it by diffusion I would have had 35 pounds more sugar per ton. This would have given me 465,000 pounds more sugar than I obtained, an aggregate of 2,865,000 pounds of sugar from about 600 acres, or 4,750 pounds per acre. The cash increase of my crop would have been, at 5½ cents per pound, $25,592.50, a difference to Mr. Johnson of $3.85 per ton of cane, and to me, on my crop, of $1.82½ per ton of cane.

QUANTITY OF JUICE DRAWN FROM EACH CELL.

The cane used for diffusion was weighed and delivered, chiefly on cars, to the cutter. The trash which becomes detached in handling the cane was collected in carts and weighed, and its weight deducted from the total. No account was taken of the trash which entered the cutter.

It was found that the average weight of chips in each cell, when filled in the ordinary manner, was 1,757 pounds. One cell filled with extra care was weighed, and the weight found to be 1,860 pounds. It was thus seen that by careful packing it was easy to get 100 pounds extra weight of chips into each cell.

The quantity of juice drawn from each cell varied from 900 to 1,000 liters, or from 2,059 to 2,288 pounds.

The mean quantity of juice drawn for the first four runs was nearly 2,170 pounds. Assuming that in each 100 pounds of chips there is

*In respect of the last run, the analytical data show that the cane worked by the mill during its last run, from which 193 pounds per ton were made, was richer in sucrose by nearly 1 per cent. than that worked at the last diffusion run.

90 per cent. of juice, we have in 1,757 pounds of chips 1,581.3 pounds of normal juice.

The quantity of diffusion juice from this was 2,170 pounds. The increase over normal juice is therefore 589 pounds, or 37.2 per cent. In the last run a much greater dilution was secured. In order to get a slow current of the juice through the calorisators the master of diffusion was instructed to begin filling the cell with juice when it was about half full of chips. At the end of the run it was found that the introduction of liquid had caused a floating of the chips, and that the weight of chips in each cell had been greatly diminished. Thus a higher dilution of the diffusion juice was secured than was intended. The very perfect exhaustion of the chips during the last run was partially secured by this means.

The mean weight of chips in each cell during the last run was 1,500 pounds; the weight of normal juice 1,350 pounds, giving an increase of 60 per cent. This dilution is greater than is necessary for diffusion work. With a battery of sixteen cells I think the dilution could be easily reduced to 30 per cent. and the extraction be satisfactory.

COAL CONSUMED.

The quantity of coal consumed depends, first, on the efficiency of the boilers and evaporators employed; second, on the quality of the coal, and, third, on the dilution of the juice.

In beet-sugar factories the method of computation is generally based on the dilution arising from drawing 180 pounds of diffusion juice from each 100 pounds of beet cuttings. In respect of evaporation what is found to be true of beet juices will also apply to cane juices of the same density.

From the arrangement of the machinery at Magnolia it was found impossible to measure the quantity of coal consumed by the diffusion work. In the last run, when the milling work was over, the centrifugals were run drying seconds and the vacuum pan boiling thirds during the process of the work.

In addition to this, a part of the steam used was furnished by the bagasse boilers, using wood and coal as a fuel—not an economical method of making steam.

As nearly as could be estimated, the quantity of coal required to make a pound of sugar was 2 pounds. The actual quantity of coal which would be required with the best boilers and evaporators may be found by consulting Dr. Karl Stammer's latest edition of "Text-book of Sugar Making," pages 873 *et seq.*

When 180 pounds juice are taken for each 100 pounds beets the consumption of coal to reduce the juice to a sirup of 60 per cent. total solids is as follows:

	Pounds.
With double-effect pan	13.50
With triple-effect pan	9.10
With quadruple-effect pan	6.76

To reduce the sirup to *masse cuite* requires 4.44 pounds.

We find, therefore, the following quantities of coal necessary for each 100 pounds raw material giving 180 pounds of juice:

	Pounds.
For a double effect	17.94
For a triple effect	13.54
For a quadruple effect	11.20

If, now, we take the ordinary dilution for sugar-cane, the following numbers are found:

In evaporating 180 pounds of diffusion juice from 100 pounds cuttings to 60 per cent. sirup, 156 pounds of water are evaporated. In evaporating 125 pounds of diffusion juice to same density, only 101 pounds of water are driven off. To evaporate 156 pounds of water 13.26, 9.10, and 6.76 pounds of coal are used for double, triple, and quadruple effects, respectively. For the same weight of cane chips, giving 125 pounds of diffusion juice, the quantities of coal consumed would be 8.58, 5.89, and 4.44 pounds, respectively. To reduce this to *masse cuite* would require the same consumption as before, viz, 4.44 pounds. One hundred pounds of cane chips will yield by diffusion an average of 10 pounds of sugar for the whole State of Louisiana. The coal consumed in evaporation, therefore, would be:

	Pounds.
For a double effect	13.02
For a triple effect	10.33
For a quadruple effect	8.88

The above computation includes the exhaust steam from the pumps, centrifugal engine, etc. The quantity of steam required to run the battery must be added to the above. It certainly would not amount to more than 2 pounds per 100 of cane used.

With the best apparatus most economically arranged the total consumption of coal per 100 pounds of cane would be:

	Pounds.
For a double effect	15.02
For a triple effect	12.33
For a quadruple effect	10.88

Reduced to 1,000 pounds of sugar from cane yielding an average of 10 per cent. of all sugars, the figures become:

For 1,000 pounds sugar—	Pounds.
With double effect	1,502
With triple effect	1,233
With quadruple effect	1,088

In all these calculations the coal is assumed to be of fair average quality, and to be able to convert 6 pounds of water into steam at usual boiler pressure for each 1 pound of coal. In general, then, it may be said the quantity of coal required to make 1,000 pounds of sugar by diffusion varies from 1,000 to 1,500 pounds, according to the system of evaporation employed.

Diffusion can only be made an economical success when the best machinery and the most economical methods are employed. The great objection which has been urged against it, viz, the increased consumption of fuel required, is entirely removed when the process is carried on under the economical conditions which have been mentioned.

To attempt to introduce diffusion with old and worn-out apparatus, defective boilers, and open pans would simply be disastrous. It can only succeed when the highest mechanical skill, associated with the best scientific control, directs all the operations of the sugar-house.

In the one experiment where actual weighings have been completed of the whole product, viz, the fourth run, the quantity of sugar made per ton is:

	Pounds.
Firsts	165.5
Seconds	45.9
Thirds	18.6
Total	230.0

I do not think, therefore, that it is extravagant to believe that with the best culture and most economical method of manufacture the yield per ton of cane in Louisiana may be brought up to 200 pounds. The introduction of diffusion means almost a complete rehabilitation of the average sugar-house. It would be unreasonable to expect that planters will have the money and the desire to undertake such a radical change, or at least to make it rapidly.

But it seems to me that the gradual introduction of diffusion, with its concomitant machinery, will work a great change in the sugar industry of the South, bringing success and prosperity where for years a hard struggle for existence has been going on.

The final result, I sincerely hope, will bring into cultivation the extensive areas of rich sugar lands now lying idle and increase the production of the State of Louisiana to 500,000 tons annually.

I can not close this report without expressing my hearty appreciation of the support I have received from the sugar-planters. The great majority of them were skeptical in respect of the process, but all were anxious that a thorough trial should be made.

Particularly I desire to thank Governor Warmoth for his constant and enthusiastic support and for generously giving $5,000 and more to continue experiments when the funds appropriated for them had been exhausted by the expensive delays caused by the cyclone and imperfections in the machinery. Without this timely aid the whole work would have been stopped on the very threshold of success.

The advice and encouragement of Messrs. Dymond and McCall, members of the advisory committee, helped me greatly during the most trying days of the work, when it seemed an almost hopeless task to wrestle further with difficulties of a purely mechanical nature.

The active co-operation of Mr. J. B. Wilkinson, jr., was a source of constant assistance during the whole progress of the work, which is but inadequately recognized by a simple sentence of thanks.

Of my own assistants, Messrs. Barthelemy and Spencer had charge of the erection of the building and of the apparatus, except that put up by the Colwell Company.

Mr. Barthelemy took charge of the sugar-making during the various trials, and Mr. Spencer had the general supervision of the diffusion process and particularly of the lime-kiln and carbonatation apparatus. Messrs. Crampton and Fake took charge of the chemical work. Mr. John Dugan was master of diffusion. Mr. R. Sieg, as consulting engineer, rendered much assistance. His long experience and thorough knowledge of the literature of diffusion rendered his services particularly valuable.

Finally, I will say that no one recognizes more fully than myself the many imperfections noticed during the progress of the experiments in the machinery and methods employed. I have endeavored not to conceal these, believing that in pointing them out a service is rendered the public only less valuable than that secured by complete success.

The success of the work at all three stations has been most gratifying, and the diffusion process for the manufacture of sugar has been advanced beyond the experimental stage by the labors of this Department, beginning in 1883, and it is now offered to the sugar-growers of the country with the confident assurance that it is the best, most simple, and most economical method of extracting sugar both from sorghum and sugar canes.

BROWN COAL AND WOOD CHAR IN THE FILTRATION OF CANE JUICES AND SIRUPS.

Report of W. J. THOMPSON.

CALUMET SUGAR-HOUSE, BAYOU TECHE, LA.,
Wednesday, February 29, 1888.

DEAR SIR: Pursuant to the conditions attaching 9 tons of German lignite furnished him by the U. S. Department of Agriculture for experimentation in cane-juice filtration at this factory, I am instructed by Mr. Daniel Thompson, its proprietor, under whose exclusive patronage the experiments have otherwise been conducted, to make you the following report concerning the same:

A miniature apparatus, comprising mill, steam defecators, open steam evaporators, subsiders, and a laboratory frame filter-press from Wegelin and Hübner, center-feed, executed in bronze, of one-half square foot filtering area, arranged for complete displacement, offered reasonable facilities at all times to small work. Four Kroog presses of thirty frames, 220 square feet filtering surface each, so mounted with respect to receiving vessels, juice, and lixiviating pumps, safety-valves, and like appurtenances as to have operated upon scums throughout the season without suggesting alteration, besides eliciting the eulogiums of the inventor of the so-called Brown coal process, served during industrial trials. All pipes were of copper or brass, pumps of bronze, and the plates, perforated sheets, frames, and other iron parts of the apparatus in contact with juice all thoroughly painted, as insurance against discoloration of products. A well-arranged chemical laboratory, unusually well equipped for investigations connected with sugar, was also provided.

Mr. B. Remmers, an English expert in mechanical filtration and sugar refining, well known to readers of the Sugar Cane Magazine, assumed technical control of the experiments, assisted by Mr. R. A. Williams, chemist from the Louisiana Sugar Experiment Station, Mr. J. P. Baldwin, a local adept in defecation, and two long-time employés of the factory.

A preliminary study was made of cake formation. For this purpose Spanish whiting, variously colored, as with aniline dyes and alizarine, kept mechanically suspended in water by vigorous agitation, was pumped into the chambers, the cakes being finished off at high pressures to insure extreme solidity, which, after removal, were cut into sections, longitudinal and transverse. It was found that, with constant or very gradually increased pressures maintained within the chambers, and a liquid kept under unaltered conditions, the cakes formed by extremely uniform accretions, beginning with a thin and even coating of the entire filtering area, over which the various colors used deposited one upon the other, as fed in succession to the press, in likewise thin and equable layers, until the chambers were quite filled and filtration ceased. With oscillatory pressures and with substances of widely differing specific gravities, such as whiting, brown coal, red lead, wood char, and ultramarine, one following upon the other, the various laminæ proved most irregular in their deposition upon the filter-bed, being comparatively of excessive thickness in parts while running out altogether in others, the plane of contact being besides often obliterated or scarcely defined, because of partial intermingling between the different substances

employed. The same effects, also, found their cause in the use of any given substance fed alternately in fine and coarse division, or at first in high followed by low percents of the matrix.

There can be little doubt that for the best results in general filter-press work, this indicates, as afterwards substantiated, for sugar liquors by the use of hydrostatic columns on the one hand and intermittency secured through means of a by-pass valve on the other, the first importance of constant pressures, freed especially from the vibratory pulsations of ordinary pumps, and a liquid so agitated while awaiting the process as to carry to the press, at all stages of this, a reasonably uniform percentage of whatever matrix is employed, the laws of hydraulics, as illustrated in silt-bearing streams, here again exhibiting themselves in complete application.

Satisfied that the mechanical arrangement of the large apparatus was appropriate to the intervention of a matrix and that the small answered to all the essential conditions of the large, systematic work with brown coal, under what is known as the Kleemann process, began on November 29. Five long tons of this article had been imported by Mr. Daniel Thompson, through the Sangerhausen Maschinenfabrik, Germany, which, however, was so superlatively unfit for its destined duty, by reason of uneven and inadequate pulverization, as to have required previous and, of course, laborious hand-sifting.

It was first sought to learn what relation varying quantities of this article bore to speed in the filtration of defecated but unskimmed juices. With this intent different percentages, based upon the estimated weight of the contained sucrose, as the most convenient, although not assuredly the most rational standard of reference, were employed with the results which follow:

Lignite, per cent. on contained sucrose.	Juice filtered per operation; 30-frame Kroog press. (Approximate gallons.)		Average time of one operation (Approximate hours.)		Average juice per press, per 24 hours. (Approximate gallons.)	Average juice per square foot; filtering area per 24 hours. (Approximate gallons.)
	Maxima.	Minima.	Filtering.	Lixiviating and emptying.		
7.5	2,800	2,900	8	3	6,220	28.3
15	2,000	2,100	6	3	5,466	24.6
22.5	1,500	1,600	4.5	2.5	5,296	24.1
30	1,200	1,300	3	2	6,000	27.2
45	950	1,050	1.5	1.5	8,000	36.3
60	700	800	.75	1	10,275	46.7

The average juice per press and per square foot of filtering surface, per twenty-four hours, stand calculated on the basis of a sixty-day continuous run. Here, taking the average weight of the juice at 8.85 pounds per gallon and its sucrose at $13\frac{1}{3}$ per cent., for percents of lignite upon sucrose contained may be substituted percents of the same on the weight of juice or pounds of the former per 100 gallons of the latter, as exhibited in the annexed scheme:

Lignite, per cent. on weight of sucrose in juice	7.5	15	22.5	30	45	60
Lignite, per cent. on weight of juice	1	2	3	4	6	8
Lignite in pounds per 100 gallons of juice	8.85	17.7	26.55	35.4	53.1	70.8

The juices treated during the interval of this work remained, so far as could be ascertained, essentially uniform as respected adaptability to filtration, as, indeed, they have done up to present writing, being referred in this regard occasionally to an arbitrarily selected standard by careful weighings of defecated juice, brown coal, and products operated upon in observed times on tarred-paper filters. The analyses of raw juices for those dates which cover this series of determinations, as made in the course of diurnal routine work, are presented below.

While they may serve for general comparison with the like as observed in other portions of our tropical cane belt, no relation has yet been noted to exist between the amounts of sucrose, reducing sugars, or other known constituents of the juice, and the difficulties exhibited by this in filtration. In the latter regard it is not possible to say if that which has here been experimented upon fairly represents Louisiana's average. It would seem, indeed, to be otherwise, since, in the treatment of scums, great difficulty is reported to have been experienced in almost if not every other local factory possessing filter-presses, while at this no other process of manufacture was throughout so satisfactorily performed.

Date.	9 a.m.				3 p.m.				9 p.m.			
	Solids.	Sucrose.	Glucose.	Exponent.	Solids.	Sucrose.	Glucose.	Exponent.	Solids.	Sucrose.	Glucose.	Exponent.
1887.												
Nov. 30	15.96	13.5	1.45	84.58	......	......	......	......	......	......	......	......
Dec. 1	15.03	12.0	1.51	79.84	15.23	11.6	1.25	76.16	15.43	12.0	1.14	77.77
2	15.30	12.1	1.27	79.08	14.78	11.0	1.09	74.42	14.43	11.7	1.33	81.08
3	15.27	12.3	1.52	80.55	14.07	11.2	1.47	79.60	13.78	9.7	1.56	70.39
5	14.09	10.4	1.62	73.81	14.69	10.7	1.50	72.83	14.91	11.5	1.36	77.12
6	14.18	10.1	1.50	71.22	14.03	11.0	1.43	78.40	14.23	11.2	1.36	78.70
7	14.06	10.8	1.45	76.81	14.58	10.7	1.50	73.38	......	......	......	......
8	14.43	11.5	1.66	79.69	14.77	11.5	1.51	77.86	......	......	......	......
9	14.63	11.7	1.56	79.97	14.69	11.3	1.38	76.92	......	......	......	......
10	13.96	11.3	1.48	80.94	14.69	11.5	1.47	78.28	14.96	11.4	......	76.20
12	15.09	11.7	1.64	77.53	15.63	12.1	......	77.41	14.00	11.6	......	82.85
14	14.17	12.1	1.61	85.39	14.93	12.1	1.66	81.04	14.20	11.3	......	79.57
15	15.03	11.9	1.47	79.17	15.09	11.8	......	78.19	......	......	......	......
16	14.63	12.5	1.66	85.44	14.69	12.9	1.43	87.81	......	......	......	......
17	14.97	12.0	1.64	80.16	14.69	13.4	1.45	91.21	......	......	......	......
19	15.16	12.3	1.35	81.13	15.43	12.6	1.34	81.65	15.29	13.6	1.22	88.94

Average solids	14.72
Average sucrose	11.68
Average reducing sugars (glucose)	1.44
Average co-efficient of purity (exponent)	79.34

Plant cane, 27.5 tons (*circa*) per acre, blown prostrate September 16.

From these trials the resulting extremes, in round numbers, have alone been given. Variations in temperatures and in pressures, both with juice and displacement water; in density and completeness of defecation with the former; in perfection of cake and lixiviation sought, as in other similar variables, some premeditated, others at times uncontrollable, render, as will be understood by a trained experimentalist like yourself, absolutely definite and thoroughly iron-clad figures quite out of the question. The average amounts of juice put through given filtering areas in fixed times have, however, in fact, most nearly corresponded with those presented as minima.

In general, it may be safely said, the most satisfactory filtrations were uniformly of juices slightly acid only, 180° F. (*circa*), under pressures which, initially low, were most gradually increased until, at finishing off, 60 pounds per square inch had been attained. Neither reasonable increase of pressure nor higher temperatures than these availed perceptibly. Boiling after the addition of the lignite produced no good result later in filtration, when intimate admixture of matrix and liquid had been maintained. Of displacement, or the depletion in sugar of the cake, more will be said hereafter.

Utterly at variance as the coal percentages and time volumes indicated are with promises which had preceded the process to this country, they proved as persistent as they are disappointing. From 30 to 45 per cent. on the estimated crystallizable product present were shown over and over again to be the smallest of coal consistent with reasonable amounts of work done in given times, with given filtering areas, whether by the experimental or the working apparatus. Upon this last from one to three consecutive defecators, of exceeding 1,300 gallons each, were repeatedly essayed. Separate treatment of skimmed liquors and their scums did no better in the aggregate. Those substances which peculiarly interfere with filtration appear to be removed only in minimum degree with the skimmings and sediments. Were this otherwise, separation and recovery of juice from the latter by filter pressing, as now practiced, would scarcely be feasible. It was the same whether with a lime, a sulphurous acid and lime, a lime and phosphoric acid, an acid sulphite of alumina, or an acid albumen defecation, under the Willcox patent, and with these re-agents in all proportions. Tannic acid extracted coloring matter from the brown coal, as did phosphoric and some other chemicals, without facilitating filtration. The use of lignite in alkaline solution is forbidden by its solubility in such. Basic lead acetate showed no better effects with the small press than the rest. Carbonatation alone succeeds, and this, as you told me, requires no lignite. Repetition, later repeated, with foreign lignite prepared under Mr. Kleemann's individual supervision and furnished by your Department, as also with native coals obtained from the Louisiana Sugar Experiment Station and other sources, comminuted at home, aggravated the disappointment. All degrees of pulverization were tried. The amounts filtered seemed tolerably constant for stubble and plant-cane juices and for juices from freshly-cut canes, and from those many weeks windrowed. From old-land cane they did doubtfully better than from new; those deteriorated as a frost effect not altogether so well, perhaps, as those not so injured. With cane freed from its adhering *cerosin*, by sand-papering prior to crushing, it went no better. Butts showed no decided superiority to middles and tops.

In all cases the filtered juices, whether from skimmed liquors or scums, or the two treated without previous separation, whether from high or low percentages of brown coal, and with whatever defecating agent employed, were exceedingly bright and clear from the first until running had quite ceased altogether. Another disappointment, however, awaited inquiry into the actual improvement as to purity secured. The exponent, on the average, was raised not materially to exceed 1 per cent. of total solids attributable to the coal, exclusive even of sweet waters. A few analyses, taken at random from the laboratory records, sufficiently illustrate this. In every case the non-filtered and filtered samples represent, as nearly as practicable, the same

juice. For the large presses these were taken in equal volumes at the discharge openings of defecators and presses, respectively, at intervals of three minutes, always so as to represent by pairs identical defecators of juice and identical defecations, before and after filtration, which, following adequate admixture of each series, as obtained from individual defecators, were resampled. This was permitted by the admirable arrangement of the coal-mixing receivers, which contained each precisely the amount from one defecator, and which were filled and emptied alternately in rotation. The effect of a thorough cake washing, the sweet water being mixed back proportionately with the filtered juice, of which it was the after-product, is shown in the last two analyses.

Date.	Defecated, not filtered.					Filtered, 30 to 40 per cent. brown coal.					Improvement in exponent.	Remarks.
	Solids.	Sucrose.	Glucose.	Exponent.	Glucose ratio.	Solids.	Sucrose.	Glucose.	Exponent.	Glucose ratio.		
1887.												
Dec. 28	16.44	13.0	1.84	79.08	14.15	16.43	13.3	1.80	80.95	14.15	1.87	Frosted cane.
28	16.44	13.0	1.84	79.08	14.15	16.03	12.9	1.78	80.47	13.79	1.39	Cake from the above used.
29	16.44	13.6	1.46	82.72	10.70	16.44	13.8	1.38	83.94	10.00	1.22	
30	17.05	13.9	1.25	81.52	8.99	16.48	13.6	1.19	82.52	8.75	1.00	Willcox albumen defecation.
31	15.00	11.7	1.44	78 00	12.30	14.70	11.6	1.40	78.91	12.07	.91	
1888.												
Jan. 2	15.00	12.6	1.20	84.00	9.52	15.30	13.0	1.30	84.97	10.00	.97	
3	15.17	12.3	1.07	81.08	8.69	15.20	12.6	1.10	82.89	8.00	1.81	
4	15.11	12.3	1.19	81.40	9.67	14.56	12.0	1.13	82.41	9.41	1.01	
10	16.46	13.5	1.00	82.01	7.41	15.96	13.3	1.01	83.33	7.52	1.32	Large presses, Willcox defecation.
17	16.44	13.5	1.10	82.11	8.17	15.12	12.6	1.02	83.33	8.09	1.22	Large presses, lime defecation.
17	16.63	13.6	.96	81.77	7.06	15.67	12.9	.83	82.32	6.43	.55	Large presses.
17	16.47	13 5	1.00	81.96	7.40	15.57	12.8	.89	82.21	6.95	.25	Large presses, pro rata of sweet H_2O included.
17	16.36	13.6	1.06	83.12	7.79	15.29	12.9	.94	84.37	7.28	1.25	Large presses.
17	16.36	13.0	.91	79.46	7.00	15.34	12.2	.83	79.53	6.80	.07	Large presses, pro rata of sweet H_2O included.
17	15.90	13.4	.98	84.27	7.35	14.78	12.5	.90	84.57	7.20	.30	Do.
Means	16.08	13.1	1.22	81.46	[illegible].31	15.52	12.8	1.16	82.47	9.06	1.01	

After that, due to the use of 10 or 15 per cent. of lignite on the weight of sugar present, no commensurate effect was observed to be produced in the direction of increased purity by the addition of further quantities. This fell off very slightly or not at all, however, as filtration proceeded towards its finishing point, as also more or less in lixiviation, depending, as seemed shown, upon a lower or higher percentage of coal employed. Believing the application of the process to Louisiana juice condemned by the excessive quantities of lignite found essential to sufficiently rapid filtration and by its failure to realize a higher gain in purity, before reaching conclusive knowledge of these minutæ it should be said these have not since been accorded that systematic inquiry which otherwise they would have deserved.

As decolorizers of saccharine liquors, either dilute or concentrated, certain brown coals are, on the other hand, surprisingly effective. In the table annexed are given to the nearest per cent. the color re-

peatedly removed from defecated juices, by varying percentages of the article furnished by your Department, referred in each series to standard samples prepared from the defecated juice dealt with by mere passage through filter paper. This paper filtration is a necessity, since suspended matter, lighter in color than the mother liquor, partly by preventing the transmission of light through this last and partly by itself reflecting light, gives invariably, in simply subsided juices, a tint too light by a number of degrees. The percentages of color removed were uniformly measured by the relative length of columns made to give the same tint as the untreated standard when contained in tubes of like glass, of caliber such as to avoid a decided meniscus, and with light of equal intensities transmitted from below in lines parallel to the columns' longitudinal axes.

Lignite, per cent. on weight of sucrose.	Length of columns, mm.	Per cent. color removed.
Unfiltered	10	....
5	28	64
10	36	72
15	50	80
20	64	84
25	80	88
30	92	89
40	100	90
50	112	91

In the foregoing the juices were treated nearly to neutrality with lime alone. With sulphurous and phosphoric acids, acid albumen, acid sulphite of alumina, or even a decidedly acid lime defecation, the percents removed were, of course, reduced, there being a less intense primary tint. No other lignite gave such high effects as that furnished by your Department. This will be seen from the accompanying approximations, obtained with from 22.5 per cent. to 25 per cent. of lignite on the weight of sucrose filtered, expressed in maxima and minima to the nearest 10, sulphur fumes having been used on the juices, the sirups not having been treated with coal prior to concentration:

Lignite, where obtained.	Per cent. color removed.			
	Juice.		Sirup.	
	Maxima.	Minima.	Maxima.	Minima.
Sangerhausen Machine Works, Germany	60	40	45	35
United States Department of Agriculture, prepared by F. Kleemann, Germany	80	60	50	40
Louisiana Sugar Experiment Station, mined in Alabama	70	50	45	35
J. B. Friedheim, Camden, Ark	60	40	40	30
B. F. Read & Co., Mineola, Tex	60	40	40	30

The higher effect of your article is perhaps attributable, in considerable measure, to a more perfect pulverization than that secured

in other samples, the degree of this exercising an undoubted influence. As was noticed in the matter of purity co-efficient, after the use of some 15 per cent. further amounts added were out of all proportion to the increase in effect. The power of lignite to absorb or otherwise destroy or remove is apparently confined to those contained substances producing particular color effects only. For these its affinity is certainly very great, animal char or bone-black, in the lower percentages, being found altogether out of comparison with it in this regard. These colors suppressed, however, by a relatively small quantity of the lignite, additional quantities produce but little useful effect, the remaining coloring matters being those for which it possesses little or no affinity. This hypothesis explains the fact that, having used so much as 30 to 45 per cent. to secure rapidity of filtration, the cake from one operation was found to have lost none of its decolorizing power upon a second application, though it no longer filtered with the same efficiency. Its influence upon the exponent, also, seemed to have diminished little by like previous use upon juice, although considerably more so after the filtration of dense sirups not first treated as juice, a fact possibly finding its explanation on the same lines. Except for the Texas sample, all the coals examined gave up a slight amount of greenish coloring matter, whether boiled in distilled water, juice, or sirup, all showing likewise an acid reaction, your own being most pronounced in the latter particular.

A hard and apparently very dry cake was obtained with whatever variety of lignite, if employed in amounts above 15 per cent. of the contained sugar, provided only ample time was accorded its formation. It was, however, in all instances of high percents, exceedingly porous as compared with scum cake finished off at corresponding pressures, weighing per press always in close proximity to the ascertained average of 670 pounds at a final pressure of 60 pounds, of which, after lixiviation at 40 pounds pressure, 49 per cent., a little more or less, was moisture.

Since with a juice polarizing 13 per cent. sucrose some 46 pounds of the latter would be otherwise lost from each pressing, equal to nearly 3 per cent. of the entire amount treated, supposing 1,300 gallons of juice to be put through, with 30 per cent. of the brown coal, at each operation, the importance of lixiviation can scarcely be overstated. No press except arranged for this supplementary process in its most complete attainment would, of course, be admissible. This work is too uniformly accomplished by steam, by reason of channels at once cut on lines of least resistance, which, besides, leaves the press too hot for immediate manipulation and severely taxes the cloths. Hot water results in too rapid and too great a reduction of the purity co-efficient, possibly because of the action of heat upon the solubility of some among the retained impurities. Cold water certainly performed best, all things considered.

The theoretical amount of so-called displacement water was found altogether inadequate. For a 30-frame Kroog press 200 liters are, for reasons not necessary to state, supposed to be the extreme limit of requirement. This amount when passed in one hour—already a serious loss of time compared with the filtration itself, which consumes but three with 30 per cent. of coal—gave at finishing off a sweet water still running at an average analysis of: Solids, 6.77; sucrose, 5.0; reducing sugars, 0.52; exponent, 73.87. Assuming the

49 per cent. of retained moisture on the 670 pounds of cake to be juice diluted to the same figures, we should have:

	Pounds.
As water	328.30
As contained solids	23.83
As dilute juice	352.13

equal to 25.5 per cent. of the cakes' weight, which would mean the loss per operation of $670 \times 0.525 \times 0.05 = 17.58$ pounds sucrose, or $352 \times 0.05 = 17.60$ pounds sucrose, or to $17.60 \times 46.1 = 811.36$ pounds sucroseper day's work of 60,000 gallons of juice, using 30 per cent. of lignite.

As a matter of fact, analysis of the cake showed this to contain 2.8 per cent. sucrose, or 18.76 pounds of the latter per pressing—a seeming paradox, dispelled by physical examination. This sufficed to reveal how the water, first finding its way past the cake on its line of contact with the iron frame, thoroughly lixiviated the extreme peripheral portions of this, afterwards to pass here in important volumes without effecting any good purpose, while yet having accomplished only a very partial depletion of more central parts. Here was met the third and last serious technical objection to lignite; one which, since it is multiplied by the number of pressings required for given volumes of juice filtered, must apply to the use of any matrix just in proportion as larger or smaller amounts of this are essential to the results sought.

There appeared to offer two methods of escape from this difficulty, each, however, involving a dilemma. Lower lixiviating pressures, while producing much better effects, prolonged the time required for the operation so far beyond the reasonable as would need double or treble the filter-press plant. Increased quantities of water employed reduced the exponent, prolonged the time, and increased the evaporation correspondingly. A third expedient was less effective, but offered some collateral advantages, to wit, more perfect pulverization of the matrix. There can be no reasonable doubt that the finer the state of division to which brown coal is reduced the more rapid becomes filtration, the more complete the decolorization effected, the more solid its cake, and the lower its final per cent. of retained juice. Sifted through the finest of millers' silk bolting-cloth, it performs better duty in every respect than otherwise. It is advisedly stated, and with positiveness, after repeated experiment, that lignite can not be too finely prepared, on a large scale at least, for cane-juice filtration, by any mechanical means at present command. Dissolved even in strong alkalis and reprecipitated as an impalpable powder, its efficiency is yet further enhanced.

As a last recourse higher juice pressures, even up to 300 pounds per square inch on the small press, were used. This, though it unquestionably left remaining a cake charged likewise with less juice and so uniformly compact as to be better adapted to displacement, again was attended with too serious a loss of time, both in finishing off and in subsequent lixiviation, to compensate the advantage in sugar redeemed or evaporation avoided. Pressures in excess of 100 pounds per square inch are, besides, not feasible in industrial practice.

A single industrial run of twenty-four hours was finally made January 16 and 17 with brown coal, with intent primarily to develop

and locate any unforeseen mechanical difficulties incident to continuous work. Numerous such arose, of course, each happily, however, suggesting at once its own certain remedy. If, technically, this large effort was not as satisfactory as might have been anticipated from the painstaking arrangements made for and well-organized and precise management accorded it, it was yet successful beyond all expectation in solving those problems which must ever attach in cane-juice work to the application in filter presses on a considerable manufacturing basis of any matrix whatever. It removed at a stroke all necessity for the yet more extensive operations which, as you know, had previously been proposed.

It is needless here to weary you with the details of this day's run, which, with its antecedents rather than with its consequents, demonstrated conclusively, as is believed, that while the filtration of the entire body of defecated juice thus, with brown coal, stands well among the mechanical possibilities, its application can by no means now conceived with us be rendered remunerative to the Louisiana industry. This your discernment will already have made quite as clear to you by what precedes as it can by any present comparison between the weights and polarizations of its resulting products and those customary to the establishment in its treatment of like raw materials. Such data, indeed, await your command, but indicate to me no variation in *rendement* beyond that attributable to the accidents and incidents common with every-day factory experience. There occurred nothing of the oft and persistently predicted clogging, either of pumps, conduits, presses, or cloths. The cloths at the end of twenty-four hours showed no loss of transmitting power, and were washed with surprising ease.

In quality of products, no doubt, some advantage was recognized to accrue, bone-coal not being employed in the factory. Notwithstanding, in this particular also disappointment was felt. In no other respect than this, surely, did the results of this experiment compare even favorably with those secured by Mr. G. L. Spencer, in 1886, with the Remmers and Williamson wood-char process, under the patronage of your Department at its Magnolia Station, as these stand officially reported in your Bulletin No. 15 (pp. 20–25, inclusive). So much more effective has vegetable char than brown coal been shown also in our own work, both as a filtering and as a defecating agent, that, having abandoned the latter altogether, experimentation since several weeks with the former, in a laboratory way, with seed-cane, has now been in seemingly successful progress here. The following is not an unfair comparison, so far as experience yet teaches, between the two articles applied to juices somewhat deteriorated by long storage of canes:

	Matrix required on weight of sucrose.	Improvement of purity co-efficient.	Decolorization sulphured.
	Per cent.		*Per cent.*
Brown coal	30 to 45	0.30 to 1.90	60 to 80
Wood char	6 to 12	1.50 to 4.30	6 to 12

Lignite presents other disadvantages, as well, in comparison with wood charcoal. Upon concentration to sirup, juice filtered with whatever percentage of it, whether reduced with the low tempera-

tures of vacuum evaporation or under atmospheric pressure, gives invariably an additional precipitate of matter probably rendered insoluble solely by the increase of density. No such precipitate has at any time, with any defecating agent, been observed after filtration with wood coal. How weak is its absorptive power, beyond that for coloring matters, is shown by the fact that, after filtration through paper alone, an improvement of but 0.03 in the exponent was secured to sirups from the ordinary lime defecation by subsequent treatment with 30 per cent. of the lignite. Below are the averages:

[Concentrated in double effect.]

Sirup.	Solids.	Sucrose.	Glucose.	Exponent.	Glucose ratio.
After primary filtration through paper	57.60	47.2	4.55	81.94	9.64
After subsequent treatment with 30 per cent. lignite	62.70	51.4	4.76	81.97	9.58
Rise in purity co-efficient with lignite	....	....	....	0.03	....

Although when freshly ground, and yet containing from 30 to 35 per cent. of hyroscopic moisture, it can be readily brought to mix intimately by mechanical means with the juices, this is scarcely to be accomplished in the large and regular quantities required if, having been long prepared, desiccation to 15 or 20 per cent. has not somehow been prevented; in which state, if sufficiently comminuted, it excels not only the kneading requirements of patent flour fourfold, but becomes even dangerous from liability to spontaneous combustion. This infers the necessity for a grinder on the premises, with engine, foundations, sifters, elevators, mixers, shafting, belting, and their like *ad libitum*, in a structure apart from the factory building proper, which last would needs be protected from the attendant dust, as another serious sugar-making complication and care. Such a plant has been estimated, by a probably competent European engineer, to cost, for a 60,000-pound diurnal output, erected upon this property, exclusive of the presses and their immediate appurtenances, but inclusive of building, not less than $10,000. Wood coal can, on the other hand, safely be prepared during the leisure of idle months, at home or elsewhere, and be mixed in the greatly reduced amounts called for, as wanted, with the most simple and inexpensive devices, or be stored without injury or danger from season to season. Even wood char, however, for satisfactory filtration, should also contain a considerable percentage of moisture when ground. Otherwise the first run of liquor is likely to come charged with the char, requiring refiltration. It appears that this, unlike lignite, may be rendered in part too pulverulent, which last the enforced presence of sufficient moisture at the time of its reduction is believed to prevent.

Brown coal, again, is not known to exert even a favorable mechanical action on the soil's productiveness; that wood char exercises valuable functions in this regard is well understood among agronomists. If in the ordinary filter-pressing of scums and sediments well-nigh the entire fertilizing content of the juice itself is already secured, leaving no credit for such properly to be conceded to either, for this mechanical advantage of charcoal something may well be deducted from its estimated first cost to manufacture. It presumably absorbs from the juice, also, fertilizing material in excess of the

brown coal, equivalent to the additional rise it secures in the exponent of this. The aggregate bulk of brown coal required would be such as might well preclude economic distribution over the fields.

Considering the quality of the native brown coals as yet examined, the cost of transportation, and, if imported, the duty upon such enormous quantities of these as are demanded, the price of vegetable char, it appears, should compare most favorably with them throughout the Louisiana sugar belt. Brown coal, in sugar work, demands also a royalty under letters patent; the patents upon wood char, in this application, have been permitted to lapse. Brown coal can not be revivified. Wood char, it is believed, can be reburned by superheated steam in any state of comminution, if found desirable. It remains to be known from the distillation of which variety of wood, however, the best quality of the last-named article for the purpose proposed is to be obtained. As saw-dust, oak is known to perform best, probably because of its excess in tannic acid.

As of application with whatever matrix employed it is pertinent only to add, as a further result of our experience in the matter, a few convictions touching the appliances best suited to the treatment of juice in considerable volumes.

The advantage of duplex, double-acting plunger pumps, extra large for their duty and operated at low-piston speeds, with exceedingly capacious air vessels and sensitive safety valves placed close to the pumps, the last of equal conducting capacity with the feed-pipes, was fully indicated. To thus insure, by every means, against sudden variations of pressure, such, especially, as the vibratory pulsations inseparable from ordinary pumping plants, seemed essential to a cake of maximum uniformity and uniformly well adapted to lixiviation in all its parts, as before insisted. With the lixiviating apparatus itself this completeness in erection is even more prominently to be indorsed, except that, as no grit is here to be encountered, piston pumps should suffice. A continuous stream of liquid running from the safety valves, both juice and lixiviating, should be maintained during operation. In the most perfect practice no approach to theoretical displacement has been found to occur. This supplementary process is, unfortunately, at the most we have been able to make it, little more than has been expressed with the word lixiviation. Whiting and highly colored liquids render its study facile.

The absolute necessity to the process of chamber presses, whether top, bottom, or central feed, and, conversely, the total unsuitability of frame presses in general to it, was left in no doubt. Each operation consumes so short an interval that a large percentage of total time is spent in emptying. A chamber press can be emptied readily in one-half the period consumed by one of the frame variety for the same number of cakes. As the cloths need be removed not oftener than twice a week, the loss from this source, in employing such, is negligible. It is not true that cloths wear most rapidly from use in chamber presses, except these be ill constructed. The tendency during lixiviation which the water exhibits, however this be fed and no matter how superlatively perfect the cake is, to cut of itself a ready and continuous channel about the cake's peripheral joint with the iron frame, has been mentioned. This results in a sludge formed along the cake's feather edges which, upon opening the press, runs more or less, despite the best effort, down the frame's sides, especially along its bottom portions, compromising the joint which this afterwards makes with its adjoining cloth. Following three rounds

with brown coal, such a press can not be made tight, and after four or five may even refuse to close, except the surfaces be laboriously cleansed with iron scrapers. In chamber presses the peripheral joint is made between cake and cloth and not between cake and iron. From this fact alone it is far more perfect. Its form, however, if properly designed, is of yet greater importance and, presenting no longer necessarily a line of least resistance, reduces the chance of sludge, besides insuring, other things equal, a more uniform and complete displacement with reduced quantities of water by preventing the formation of such water channels as those before described. If by any chance a small amount of semi-liquid material here runs in like manner, notwithstanding, this interferes in but half degree with a press joint now made between two thicknesses of the fabric instead of between iron and one such. Although in top and bottom fed chamber presses the liquor inter-ports of the individual chambers may be of greater diameter than those possible with frames, yet from liability to obstruction the center feed is to be preferred.

Any filter press constructed for the use of brown coal or any of its congeners should be recessed for $1\frac{1}{4}$ instead of for 1-inch cakes. This statement will not remain true except that in all cases the wisdom of employing the matrix in excess is confirmed. A yet greater thickness in these might then perhaps prove still more advantageous were it not the limit at which, in such presses, the cloths have been made to stand. Without attempting an explanation of the fact, it remains that, with chambers of increased thickness, higher results per square foot of filtering area are attained, this dimension even doubled, curiously enough as it would seem, requiring but a very small fraction more of time for cake completion than before, so long as a slight excess only of matrix is in each instance employed. This is best illustrated in starch manufacture. Speed in filtration is, then, increased by this innovation, except for deficiency of matrix; a relative reduction in the amount of sweet water to be dealt with is secured and proportionate time is saved in emptying.

Since it consumes no more time to empty thirty chambers presenting 400 square feet of filtering area than thirty aggregating but 220, presses of the former size should alone be used for the purpose under consideration. Such are decidedly cheaper in first cost per square foot of filtering surface; are as readily handled and kept tight, and require, proportionately to the work done, fewer laborers. They occupy scarcely more space.

The presses should be worked in batteries after the English plan, instead of by rotation, as practiced in Germany. This avoids a fall of pressure, with consequent loss of time and a cake ill suited to lixiviation in the other active presses, when one freshly prepared is set in operation. It also permits, which is of much consequence, low pressures at the start, which are gradually increased to high at the finish, a practice precluding all attempt at governing the pressure at the pump's throttle by an attached pressure regulator.

A precipitate invariably following evaporation, by whatever means accomplished, of juice filtered through brown coal, the filtration of sirup was accorded some study. For this purpose from 12 to 15 per cent. of lignite on the weight of sugar operated upon was found necessary to satisfactorily rapid work, previous treatment notwithstanding. Again the improvement in purity was not marked, averaging 0.82; that in color being the more conspicuous result, at about 40 per cent. of this removed.

For sirups from unfiltered juices the ratio of lignite had, of course, to be increased until percentages approaching those employed with juice had been attained. Equal amounts would probably have been necessary, in terms of sugar, except for scums removed and some 8 to 10 per cent. of the juice itself already filtered with these, decantation of clear liquor from skimmings not having been practiced. Mere bulk, thus, in the filtrate, was seen to exercise no perceptible influence in this work. The dilution of sirup by the addition of water in any amount can, of course, in no wise reduce the quantity of coal required, which is determined alone by the quantity and quality of non-sugar dealt with. Neither the net result in purity nor in color was equivalent in filtered sirup from unfiltered juice to that secured in unfiltered sirups from filtered juice. The glucose ratios of sirups first filtered as such were always considerably higher than those of unfiltered sirups derived from filtered juices of like quality. It is supposed that by the filtration of juice, though this is left in all cases more acid by the process, certain active inverting agents are removed, thus reducing the losses otherwise sustained in concentration. The brown coal also removed an amount of reducing sugars relatively larger than that of sucrose lost in the operation, the glucose ratio being almost uniformly lower after than before filtration, whether of juice or sirup. The ash is also reduced.

Not above 550 gallons of sirup from unfiltered juice could be put through a 30-frame Kroog press with 25 per cent. of brown coal on the weight of its sucrose at one operation, this, complete, occupying about four hours. A $\frac{7}{8}$-inch frame or chamber was found ample in the treatment of sirups, but even for this work 400-foot presses, it is thought, would be preferred. Thinner frames would be necessary with reduced percentages of lignite. Lower pressures than those mentioned for juice gave the more satisfactory results, which also should be extremely steady.

The cake from sirup filtrations following that of the juice, with or without lixiviation, when mixed with the amount of fresh coal necessary to bring the total of this to the usual standard, was found to perform about as well on a fresh supply of juice as an equal total of fresh coal, the amount of the latter being thus proportionately reduced. In practice this would obviate the difficulty of sweet water from the sirup filters. Wood char was given no trial in connection with concentrated liquors. The whole subject of sirup filtration in filter presses merits more thorough investigation than circumstances have yet permitted at this factory, although success with such can scarcely supplant the far greater necessity for previous treatment of the juices.

Experiments, by no means exhaustive, were also made with the Bauer process. This failed from the first. The mucilaginous impurities, passing through the interstices of the bone char, reached and occluded at once the pores of the cloth, thus bringing operations to a speedy termination with every trial. The cloths were washed with great difficulty. To fully meet every prejudice the entirely inutile use of various fabrics was resorted to. With bone-black, from coarse to finest, the result was always the same. Indeed, as is well known, animal char in sugar work is an extremely poor filtering medium, no matter how skillfully revivified, and except for the preliminary Taylor or bag filtration could scarcely be used after the manner or in the percents at present common except upon the highest centrifugal goods, even in the refining of sugars from which the

major portion of non-sugar has already been removed, upon the plantation, in scums, sediments, and molasses—substances which are yet left remaining with us in our treatment of juices. It is imperative with this article, in our work at least, that it be used in quantities quite beyond the utmost ability of filter presses to accommodate.

Notwithstanding the meager results as yet secured, eventual success in the economic mechanical filtration of the entire body of defecated juice is not altogether despaired of. Its difficulties have been greatly underrated. All the juices thus far dealt with have been the product of milling under pressures attaining from 65 to 78 per cent. of these upon the weight of canes crushed. So successful throughout has been the routine work in this establishment with skimmings and settlings from all manner of canes and with many modes of defecation, and so small has been at any time the immediate improvement in the purity co-efficient attributable to it, and yet, by comparison, so easy and rapid a second filtration, as to have forced a conviction that in but an exceedingly small part of the total non-sugar resides well nigh the whole difficulty. This probably minute portion of especially refractory material has been traced as an insoluble, suspended impurity to raw juice direct from the rolls, which presents in the filter practically all the perplexities encountered after defecation and may be followed thence quite to the molasses. The microscope has not identified it at 100 diameters. Fermentation fails to remove it. Although itself probably inert and harmless, it suffices to render most difficult or altogether impossible a process which, in effecting an immediate improvement, if only of several points in the exponent, would yet suffice before the by-product was reached to add directly or indirectly a decided increment to the otherwise possible *rendement*. Your success in filter-pressing carbonated diffusion juices this season of 1887–'88 at the Magnolia Station leads to the hope that this small part, whatever it may be, is either in great measure eliminated from the artificial juice by diffusion, or else is amenable to chemical treatment (other than carbonation), such as it is reasonable to suppose will not escape adequate research. In either case the benefit to accrue would become important to the local industry, the substitution of osmosis for pressure in juice extraction by large central factories now seeming as if eventually inevitable.

It is proposed by the proprietor that the investigation of this subject shall continue at this place uninterruptedly throughout another season. At his desire I express the hope that it may not be impossible with you to detail a chemist from your department to aid in this search for an improved defecation. It is not to be overlooked how, to the present, your Department, in pursuing its inquiries with respect of sugar manufacture, has neglected altogether the sulphur regimen universally found in Louisiana's practice, excepting only at its previously chosen station.

With much respect, sir, I am yours, very truly,

W. J. THOMPSON.

Dr. H. W. WILEY,
Chemist, U. S. Department of Agriculture,
Washington. D. C.

INVESTIGATION OF FOOD PRODUCTS.

CERTAIN PLANTS OF ECONOMIC VALUE AS FOOD FOR MAN AND STOCK IN TEXAS AND NEW MEXICO.

By CLIFFORD RICHARDSON.

During the past few years several plants have been brought to my attention which are in use for forage purposes or as food for man in Texas and New Mexico. They belong to the genera *Opuntia*, *Dasylirion*, and *Agave*. One of the *Agave* species has been superficially examined from a chemical point of view by O. Loew in his reports to the Wheeler survey.* It is not of agricultural importance, that I am aware, but it is of interest because of its chemical relations to the others. The *Dasylirion* species, known as Sotol, I have already noticed in the Annual Report of the Department of Agriculture for 1883, pages 242–244. It belongs to the family *Liliaceæ*. Generally described it consists of a caudex 2 to 5 feet high, bearing a rosette of light-green leaves 3 or 4 feet long and $\frac{4}{10}$ to $\frac{5}{10}$ inch broad, expanding into a fleshy base 1 to 2 inches broad, and a flowering stem 8 to 10 feet long.† It is the fleshy bases of the leaves, forming a dense cabbage-like head, which are used for feeding purposes. The outer are black and hard, while the inner are yellowish-white and succulent. The heads weigh 6 or 7 pounds, of which the soft edible portion forms one-third. The shepherd splits the head open with a knife, after which the sheep or cattle readily get at the succulent interior, and in time become accustomed to pull off the outer leaves. Sheep living on it can exist without water in winter for four or five months. It is eaten by man, when prepared by roasting in pits, after the manner of the *Agave*. It is also fermented into a mescal or highly intoxicating liquor, known from the name of the plant as "*Sotol mesal.*"

The plant grows abundantly in western Texas and Mexico on rocky and gravelly soil, and flourishes in the driest seasons. An investigation of the soft interior showed that about 40 per cent. of juice may be expressed from it, which is sirupy, and consists of over 30 per cent. of solid matter, corresponding to sugars, equivalent to—

	Per cent.
Reducing sugar, as dextrose	.66
Sugar, reducing after inversion, as sucrose	26.44

An examination of the whole head showed the presence of between 15 and 16 per cent. of sugars. The reducing sugar resembles dextrose, but the principal sugar is not sucrose, since the juice polarizes 30° to the left before inversion, marking it at once as new, since no non-reducing sugar of such rotatory power is known. It is readily inverted, even on boiling, with production of a substance other than sugar, besides the reducing matter. The plant is therefore distinguished by the presence of a large amount of a glucoside readily decomposed, and which could be further investigated with interest.

The agave examined by Dr. Loew was also found to contain a large amount of a similar substance. It was a species related to

*Reports of the Surveys West of the 100th Meridian. Lieut. G. M. Wheeler in charge. Vol. III, Geology, 610, 611.

† Watson, Proc. Amer. Acad., xiv., 249.

Agave decipiens called *Maguey* or *Mescal,* and used by the Indians as food. Of it he says:

The undeveloped leaves are folded into each other like a bud, and are perfectly white and soft as long as no sunlight reaches them. The taste is sweet, afterwards somewhat biting. These heart leaves when exposed to heat assume a very sweet, at the same time sour taste. When roasted several hours, they become soft enough to remove the fibrous portions.

There is no peculiar smell, and the change is like that of no known substance. No starch or similar matter is present, and a reducing sugar is formed without the aid of acid, although none is originally present. Mere boiling with water is sufficient. The products of the inversion were proved to be dextrose or a similar reducing sugar and citric acid. The peculiar substance is therefore a glucoside. The sugar in *Dasylirion* and that of *Agave* are so much alike that, being derived from such similar plants, their relation is of interest.

The *Opuntia* species, which was next examined, it was thought might resemble the two preceding plants. The specimens which were forwarded to Washington were sent through the courtesy of Hon. A. J. Dull, of Harrisburg, Pa., with the request that an analysis be made, as the plant was of importance for forage purposes and was attracting some attention in southern Texas. The species was not identified with certainty, but was either *Opuntia tuna* or one closely allied. It is known by the Mexicans as *Cacannapo,* and in this country as cactus or Prickly Pear, the succulent joints, not properly the leaves, being the portion of value for fodder. The results of the ordinary fodder analysis were sent to Mr. Dull with the comment that the material showed a deficiency in albuminoids, and should be combined for feeding purposes with substances rich in nitrogen. At the close of the season a reply was received in regard to the results of the use of the plant from Dr. A. G. Carrothers as follows, which explains the peculiarities and uses of the different *Opuntia* species.

In compliance with your request of July 27, I send to-day by mail specimens of the thick cactus known by the Mexicans as *Napal de Buey*, or the "Cactus of the Ox," together with specimens of its fruit, the flowers being unattainable at this season, collected at Iuka Ranch, La Salle County, Tex., 28 miles north of Mr. Dull's ranch. As to practical information in regard to the application of the plant as fodder in Texas and Mexico, I will state that I have studied this matter for a couple of years, believing that it possessed a considerable food value.

While living in Mexico I saw that the Mexican teamsters, who did the freighting of the country with oxen, were able to work their steers all winter and keep them in good condition by collecting the pear leaves, burning the thorns off them, and feeding them to the oxen. I found the Mexican freighters in Texas doing freighting on the same food, alongside of the Americans who were feeding high priced corn to their animals, and maintaining their animals in as good or better condition than their competitors. From this I concluded that the Prickly Pear was rich in growth producing elements.

About 1878 or 1879, while on a visit to the Leona Ranch Company in Zarella County, Tex., the foreman told me that he had just received a consignment of 52 thoroughbred and high grade Durham bulls from Kentucky, late in the fall, and did not know how to feed them. They cost about $150 each. I advised him to scorch the thorns off the pear leaves, chop them up, put them into troughs, and sprinkle them with corn-meal and salt, and feed them to his bulls at night, allowing them to graze on the Mesquite grass (*Buchloë dactyloides*) during the day. He did so, and next year he assured me that his bulls wintered in good style, and were fat and vigorous the next spring. His wife also volunteered the information that she thanked me for the suggestion, as she had fed some of her milch cows on the same food and that she had made as fine butter all through the winter as she had ever made in Illinois. Since that I have fed my milch cows at the ranch on the scorched pear alone, with marked benefit to their milk and butter-producing qualities. Several

of my friends have done so with like results. My foreman tells me that his father, as an experiment, shut up some hogs and sheep in a pen in July, and gave them no food or water for six weeks except what they derived from the scorched pear leaves, and that they greatly improved in flesh during the time. About sixteen months ago (April, 1885) I asked the pastor of 3,000 sheep grazing on some of my land when he watered his sheep. He replied that he gave them no water except what they got from the pear, and that they had not seen water since the previous October, for six months, at shearing time. I have since verified his statement, and it is well known that sheep and cattle can subsist indefinitely upon the pear in the winter months. During the severe drought of last winter and the previous one many thousands of cattle were fed upon the scorched pear leaves, but it was the universal experience that it was necessary to give some species of "roughness" with it; that if fed alone it would not be assimilated, and would cause "scouring" or diarrhea. On the Nueces River, below my ranch, thousands of trees covered with Spanish moss were cut down for the moss as a food for the cattle in conjunction with the scorched pear leaves. The moss is not regarded as possessing much nutritive value, but rather as the diluent and bond of union to the pear, to enable the animal to properly ruminate it. Colonel Miller, member of Congress from Gonzales district of Texas, who owns the finest herd of Holstein cattle in the State, tells me that he has fed his entire Holstein herd of about 80 head for the past five years on the leaves of the Prickly Pear thoroughly cooked with cotton-seed. He covers the bottom of a large sheet-iron box with the scorched and chopped pear leaves, filling it about two-thirds full of pear, then fills the box with cotton-seed, throws a few bucketsful of water into the box, builds a fire under it, and cooks the cotton-seed with the steam which arises. He assures me that his cattle keep fat all winter upon a small pasture which could not otherwise support them. Judge Blackburn, of Burnett, Tex., gives me substantially the same statement, from feeding it to a herd of imported cattle. The Dolores Land and Cattle Company, composed of my brother, W. S. Carothers, and my cousin, G. A. Searight, of Austin, have fed it for the last three years to some three or four car-loads of Hereford cattle which they have brought to Texas from Iowa, and find it a valuable food, and also believe it to be almost a specific in the prevention of the impaction of the third stomach and hemo-albuminuria, called Texas fever, from which animals brought from the North are apt to suffer. I imported 41 head of Hereford bulls last January, and found the cooked pear of great utility in preventing the same trouble. I could multiply instances of its supposed utility, but these are the principal ones that have come under my direct observation.

My conclusions are: (1) That it is not a perfect food. It must be supplemented or complemented with other articles, especially with hay or grass. (2) That while your chemist found no starch present, he found the metamorphic stage of starch, glucose, which is most readily assimilable in the stomach of all animals, and the condition to which starch must be reduced by the action of the salivary and pancreatic secretions before it can be assimilated. (3) That it is deficient in the nitrogenized albuminoids, contrary to my preconceived opinion. (4) That whatever its food value may be, it undoubtedly aids in the assimilation of more highly nutritious foods, possibly by some catalytic action or by emulsifying the fats that they contain. Colonel Miller is very positive in his conclusions upon this point. Gum and glucose make a perfect emulsion with all fats.

The presence of the "glucoside body" explains two facts that have lately come to my knowledge: (1) That a neighbor of mine, a Frenchman, has succeeded in making a palatable and intoxicating wine from the fruit of this cactus. (2) That alcohol has been distilled by a chemist in San Antonio from the bruised and fermented leaves of this plant to such a degree that it has been discussed as a possible source of alcohol. There are several points upon which scientific information, such as you can give, would be of great value to Texans.

First. The substances with which this cactus can be combined to make it a perfect food for the purpose of fattening beef. We have available in our section the following articles:

(*a*) Mesquite grass (*Buchloë unioloides*).
(*b*) Grama grass (*Bouteloua oligostachya*).
(*c*) Johnson grass (*Sorghum halapense*).
(*d*) *Sorghum—saccharatum* and other varieties.
(*e*) Cotton-seed oil meal.
(*f*) Corn-meal.
(*g*) Our pasture grasses, annuals, as the varieties of *Andropogon*, *Paspalum*, and *Panicum*, especially *P. texanum*.

Now, if we can make a combination of the above enumerated articles and the Prickly Pear, we can mature our beef on our own ranges. I send specimens as follows:

No. 1. A leaf of last year's growth.

No. 2. A leaf of this year's growth.

No. 3. An old leaf cut from near the main stalk. This is supposed to be more nutritious than the others, and is the part that horses will eat if cut up fine for them. I regard this as of interest.

No. 4. Specimens of the fruit, the last of the season.

I have been unable to procure specimens of the thin-leafed cactus, the *Cacanapo* of the Mexicans that Mr. Dull sent you, as it only grows upon thin black land, whereas my land is a rich, sandy, red loam. I shall, however, procure the *Cacanapo* as soon as possible, and send it to you. It may be well to note what may be, and probably is, a popular superstition in relation to the fruit of these two varieties. It is believed that the fruit of the *Nopal de Buey* which I send you will cause, if eaten, chills and fever (*Febris intermittens*), while that of the *Cacanapo*, a smaller and lighter colored fruit, is innocuous, and is used by the Mexicans as an article of diet, while they will not eat the other. It may also be worthy of attention that the cochineal insect is only found upon the *Nopel de Buey*, of which I send a specimen, and never upon the *Cacanapo*. I would also like to correct a misapprehension in your letter. It is not an "arid" region in which this cactus exists. We have an annual rain-fall of from 24 to 26 inches, and usually raise good crops of cotton, corn, and nearly all the cereals. I have raised stalks of Johnson grass 9 feet high, within 100 yards of where I cut the samples of pear that I send you.

I fear that I have extended this report to such a length as to weary you in reading it, but what I believe to be the importance of the subject must be my apology. I am secretary of the Southern Texas Live Stock Association, own a large ranch, and have my entire capital embarked in stock-raising, hence I am greatly interested in the matter and in everything pertaining to it. I would regard it as important if you would have an analysis made of the different parts of the cactus before and after cooking the same. Congressman Miller is quite positive from his experience that cooking greatly increases the food value of this substance, and I think it not improbable. We have familiar examples in the process of panification, in the making of "*pinole*" by toasting the kernels of corn and rice, in the roasting of peanuts, and other similar cases. In all of these the quantity of sugar or its congeners is increased.

Could you give me the quantitative analysis of the glucose in same specimen before and after cooking? I am at your command for any further information you may require, and should this investigation be attended with any expense I will cheerfully meet it.

Yours, truly,

A. G. CAROTHERS, M. D.

U. S. DEPARTMENT OF AGRICULTURE,
Washington, D. C., October, 1887.

Later Dr. Carothers wrote:

In pursuance of the correspondence of last summer, begun by Mr, A. J. Dull, I have fed 400 beeves and am now feeding 800 more on this food. From the analysis furnished I found the cactus was deficient in the nitrogenous albuminoids, and from the well-known richness of the cotton-seed oil cake in these elements, I selected it to supply the deficiency, which it did very satisfactorily.

I first burned the thorns off the cactus, then cut it up by a machine which I devised, and spread it in large troughs, scattering the cotton-seed meal over it, when the cattle ate it with great avidity. I soon found, however, that the burning was injurious, as it was impossible to conduct it without cooking the cactus to a greater or less extent, which caused purging in the animals. To remedy this, *i. e.*, to destroy the thorns without scorching, I took advantage of the botanical fact that the thorns of *O. Engelmanni*, the only one I use, are set at about an angle of 60° backward to the plane of the leaf, and that a cut of one-half inch in width would strike every one of them and destroy them. I therefore set the knives of my machine to a one-half inch cut, and find that the cattle eat it fully as well as when scorched, with none of the unpleasant results referred to. I have fed about 60 pounds of the cactus and an average of about 6 ponnds of the meal per capita for ninety days. A train load of 330 head of these cattle sold last week in Chicago at 4¼ cents. The meat is singularly juicy and tender, the fat well distributed among the muscles. I have sold it at 1 cent gross over grass cattle in San Antonio.

A. G. CAROTHERS.

Others have more recently expressed, at the request of Dr. Vasey, their opinions in regard to the use of Opuntia, which have been published in Bulletin No. 3 of the Botanical Division of the U.

S. Department of Agriculture. The experience of nine or ten observers has been varied. It is fed especially in winter, cattle, sheep, hogs, and goats living upon it. At times it is fed as found upon the range, but difficulties, as Dr. Carothers remarks, have been met with by most cattlemen on account of the spines and with their removal by burning and the consequent purging, although others have never experienced the latter defect. As a whole, however, the success met with in its use has been marked, and as it grows in such large amounts and so readily in those portions of the country where corn can not be obtained, it must become of considerable value.

With a view to throw some light upon its rational use as a forage plant, its analysis was undertaken for Mr. Dull and carried rather further, for the purpose of comparing it with *Dasylirion* and *Agave*, and as being a representative of a class of plants of which little is known.

The results obtained from an ordinary fodder analysis of two specimens of the *Cacanapo* or thin-leaved Prickly Pear, probably *Opuntia tuna*, from Waugh's Ranch, La Salle County, Tex., was as follows:

	Old thick specimen.		Young thin specimen.	
	Fresh.	Dry.	Fresh.	Dry.
Water	85.93	....	86.88	....
Ash	2.94	20.84	2.40	18.36
Fat	.13	.98	.11	.82
Crude fiber	.90	6.37	.53	4.04
Albuminoids	.51	3.63	.78	5.91
Nitrogen-free extract	9.59	68.18	9.30	70.87
	100.00	100.00	100.00	100.00
Per cent. of N. as non-albuminoid	....	30.0	....	22.6

As has been remarked, it is deficient in nitrogen, and should be fed together with cotton-seed meal and the grasses which fortunately are common and cheap in the country where the Opuntia grows, and supplies the deficiency in oil and albuminoids.

With the view of determining the proximate principles of the plant, and discovering the character of the non-nitrogenous extract and the causes of purging in the roasted specimens, a more thorough analysis was undertaken. A microscopic examination showed that the structure of the joints consisted of an outer, thin cuticle, growing thicker in older specimens, followed by a row of round, longitudinal cells running lengthwise of the joints, and then a row of shorter cells running crosswise, delicate in the young plants, but quite woody in the older ones. Below these there is a series of long, round cells running through the joints till the parenchyma, which forms the main body, is reached. Through the latter run fibro-vascular bundles, and near its juncture with the outer coats are scattered starch grains. The largest portion of the nitrogenous substance is in the fibro-vascular bundles, which form the frame-work of the plant, and probably give, with the outer coats, the fiber mentioned in the analysis. The cellular structure of the interior is small and delicate.

The joints weighed—

	Grams.
Old and thick specimens	731
Young and thin specimens	650

The results of the more detailed proximate analyses were as follows:

Approximate analyses of Opuntia species, Cacanapo.

	Older and thicker specimen.			Younger specimen.		
	Original substance.	Dry substance.		Original substance.	Dry substance.	
Water	85.93	....		86.88	....	
Ash:						
Insoluble	1.76	12.48		.90	6.88	
Soluble in water	.80	5.66	20.84	1.22	9.32	18.36
Soluble in 80 per cent. alcohol	.38	2.70		.28	2.16	
Volatile oil, ether extract	.01	.08		.01	.06	
Solid soft fat, ether extract	.12	.90		.10	.76	
Aromatic bitter resin, 80 per cent. alcohol extract	.13	.98		.11	.84	
Organic acid, 80 per cent. alcohol extract	.53	3.74	25.43	.68	5.19	20.01
Glucoside, etc., 80 per cent. alcohol extract	3.05	21.69		1.94	14.82	
Vegetable mucilage and organic salts containing ash, water extract	1.59 [.80]	11.31 [5.66]	16.97	3.03 [1.22]	23.08 [9.32]	32.40
Soluble in acid, pararabin, starch, and oxalate of lime	2.84	20.17		3.09	23.57	
Soluble in alkali	1.45	10.34		.44	3.37	
Crude fiber	.90	6.37		.53	4.04	
Crude albuminoids	.51	3.63		.78	5.91	
Nitrogen	....	.58		....	.86	
In alcohol extract	....	.084		....	....	
In water extract	....	.056		....	....	
In lactic acid	....	.174		....	.195	

It will be seen that, as in the *Dasylirion* and *Agave*, a glucoside was found. This also rotates the ray to the left, and is readily inverted with the formation of an acid. It was obtained in small amount in crystalline form, but not sufficient for extended examination. Owing to its partial decomposition the alcohol extract of the plant has an acid reaction. The other prominent constituent of the nitrogen-free extract is a vegetable mucilage which is present as a magnesia compound, the latter being a prominent ash constituent. The value of this as a nutrient is uncertain, and the presence of so much magnesia may cause the purging, which would then be greater with the younger plants, which agrees with the opinion that the plant is more so when the sap is in it. The mucilage polarizes left-handed, but less so after treatment with acid. It is precipitated by one volume of alcohol from water, but not by lime-water.

There seems to be some relation between the glucose and mucilage in the plant, for where one becomes abundant the other diminishes proportionally, the younger portions containing more mucilage and less glucoside.

Of other constituents it was observed that the alkalinity of the ash of the leaves corresponded to the following amounts of organic matter in the plant, calculated as oxalic acid:

	Per cent.
Older leaves	11.05
Younger leaves	29.54

An examination showed that the acid present was not largely oxalic, but some other forming a soluble lime but insoluble lead salt; in fact probably a mixture of several.

The fat was of a nature solid at ordinary temperatures, but small in amount, and accompanied by a trace of volatile oil.

The substance insoluble in water but soluble in dilute acid was in part nearly related to pararabin, together with a little starch and

some oxalate of lime. The alkali extract was not identified, but was much larger in the older specimen, and is probably of a nature allied to cellulose or the material forming the cells.

The alcohol extract gives a heavy precipitate with basic lead acetate, organic salts, a cloudiness with mercuric nitrate, and a slight brown with copper acetate on boiling. The resin insoluble in water but soluble in alcohol is soluble in ammonia and precipitated by acid. To what to attribute the purging is uncertain. It may be due to the acid produced by the inversion of the glucoside, to the large amount of mucilage and magnesia, or to the organic acids present in such large amounts. Dr. Carothers's specimens, which, as he states, were different from Mr. Dull's, were identified as *Opuntia Engelmanni*. Being supplied in several stages of development of the joints and fruit, they furnished material for a more thorough study of the variations in the composition at intervals in the growth of the plant, as well as for comparison of the two species and the effect of cooking.

The joints varied in dimension and weight, in accordance with their age. The specimens were weighed and measured, with the following results:

	Thickness.	Length.	Width.	Weight of one.
	Inches.	*Inches.*	*Inches.*	*Grams.*
Growth of the year	1.25	....	....	1500
Growth of previous years	.75	12	9	1511
Old stem joint	2.00	....	5	2093
Old fruit	....	....	....	66
Younger fruit	....	....	....	49
Youngest fruit	....	....	....	28

The growth of the year was much thicker and narrower than that of the previous year, and in consequence, as appears from the analysis, more succulent. These two samples appear not to be strictly comparable as representing these two stages of development. It would have been more desirable to have selected joints developed more on the same plan. The oldest fruit was ripe and purple, the younger just tinged, and the youngest quite green.

The analyses resulted as follows:

Analyses of the joints and fruit of Opuntia Engelmanni at various stages of growth.

JOINTS.

	Growth of the year.				Growth of previous year.				Old stem joints.	
	Natural condition.		Steamed.		Natural condition.		Steamed.		Natural condition.	
	Orig. sub.	Dry sub.	Orig. sub.	Dry sub.	Orig. sub.	Dry sub.	Orig. sub.	Dry sub.	Orig. sub.	Dry sub.
Water	86.00	......	88.00	......	93.50	......	90.00	......	86.00	......
Total ash	3.27	23.38	2.18	18.21	1.18	18.09	1.60	15.98	1.77	12.64
Oil	.88	6.26	.76	6.30	.48	7.31	.66	6.63	.27	3.27
Resin, etc	.33	2.39	.24	2.00	.14	2.12	.30	2.95	.46	1.89
Glucoside and organic acid	1.05	7.48	1.10	9.19	.90	13.88	1.04	10.39	2.01	14.40
Ash soluble in alcohol	......	[2.61]	......	[3.36]	......	[6.00]	......	[3.98]	......	[4.29]
Mucilage	1.92	13.69	1.45	12.14	.60	9.27	1.11	11.10	.58	4.14
Ash	......	[7.13]	......	[6.16]	......	[4.19]	......	[5.46]	......	[1.75]
Crude fiber	1.11	7.90	1.09	9.01	.80	12.27	1.39	13.96	1.97	14.07
Albuminoids	1.16	8.29	1.02	8.46	.50	7.81	.80	7.95	.79	5.66
Undetermined	4.28	30.61	4.16	34.69	1.90	29.25	3.10	31.04	6.15	43.93
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Nitrogen	......	1.33	......	1.35	......	1.25	......	1.27	......	.91
Non-albuminoid nitrogen	......	.31	......	.34	......	.48	......	.64	......	.42
Per cent. of nitrogen as non-albuminoid	......	23.3	......	25.2	......	38.01	......	50.0	......	46.4

Analyses of the joints and fruit of Opuntia Engelmanni, etc.—Continued.

FRUIT.

	Last of season.		Younger.		Youngest.	
	Steamed.		Natural condition.		Steamed.	
	Orig. sub.	Dry sub.	Orig. sub.	Dry sub.	Orig. sub.	Dry sub.
Water	86.00	....	85.00	....	85.00	....
Total ash	1.60	11.44	1.89	12.58	2.22	14.79
Oil	1.58	11.25	1.87	12.45	1.72	11.48
Resin, etc	1.77	12.66	1.08	7.21	3.14	20.96
Glucoside and organic acid	1.27	9.16	2.01	13.41		
Ash soluble in alcohol	....	[3.23]	....	[4.02]	....	[4.25]
Mucilage	1.00	7.10	.75	5.00	.71	4.75
Ash	....	[2.79]	....	[3.09]	....	[3.46]
Crude fiber	2.70	19.29	2.81	18.73	3.08	20.54
Albuminoids	.74	5.20	.88	5.86	.93	6.17
Undetermined	3.34	23.90	3.71	24.76	3.20	21.31
	100.00	100.00	100.00	100.00	100.00	100.00
Nitrogen	....	.83	....	.94	....	.99
Non-albuminoid nitrogen	....	.17	....	.10	....	.15
Per cent. of nitrogen as non-albuminoid	....	21.1	....	10.3	....	14.7

The determinations show considerable difference between the two species. The *Opuntia Engelmanni* has much more oil or fat and albuminoids, but less glucoside or gum than that previously analyzed, and in the old joints the mucilage largely disappears. The percentage of crude fiber is also slightly greater in the *O. Engelmanni*. When calculated to the original percentage of water as mere fodder analyses, the results appear thus :

	Growth of the year.				Growth of previous year.				Old stem joints.	
	Natural condition.		Steamed.		Natural condition.		Steamed.		Natural condition.	
	Orig. sub.	Dry sub.	Orig. sub.	Dry sub.	Orig. sub.	Dry sub.	Orig. sub.	Dry sub.	Orig. sub.	Dry sub.
Water	86.00	....	88.00	....	93.50	....	90.00	....	86.00	....
Ash	3.27	23.38	2.18	18.21	1.18	18.09	1.60	15.98	1.77	12.64
Oil	.85	6.26	.76	6.30	.48	7.31	.66	6.63	.27	3.27
Crude fiber	1.11	7.90	1.09	9.01	.80	12.27	1.39	13.96	1.97	14.07
Albuminoids	1.16	8.29	1.02	8.46	.50	7.81	.80	7.95	.79	5.66
Nitrogen-free extract	7.58	54.17	6.95	58.02	3.54	54.52	5.55	55.48	9.20	64.36
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Per cent. of N. as non-alb	....	23.3	....	25.2	....	38.1	....	50.0	....	46.4

The amount of nitrogen-free extract is decidedly smaller, and the nutritive ratio a more nearly normal one than in Mr. Dull's species, undoubtedly making it of greater value and necessitating perhaps only the amelioration of its physical consistency to make it by itself a suitable cattle food. The larger amount of water in the growth of the previous year is due to its greater thickness, which, however, in the old stem joints is neutralized by their more woody nature.

In the *O. Engelmanni*, as in the other species, the glucoside increases with the age of the plant, accompanied by a corresponding

diminution of the mucilage. The albuminoids, as would be expected, diminish in the older joints, but the percentage of non-albuminoid nitrogen increases. In the same way the ash, oil, fat, or resin decrease, and the fiber increases, all in the same manner as in other plants. In the fruit also the changes are those to have been expected.

The results obtained by steaming do not explain the purging effect, and without a more thorough study of the products it must be attributed to the increased acidity. The changes make the constituents of a joint of the previous year's growth less soluble in alcohol, but the reverse is the case with the growth of the first season; there is reason, however, to believe that this may merely be apparent and due to the difficulty of selecting exactly comparable specimens for analysis in the natural and cooked condition, and changes produced in drying the moist material.

The entire investigation can make no claim to completeness, having been undertaken at moments when no other official work interfered, but will serve to call attention to a plant which is of considerable economic importance and scientific interest from its relations to others of the same region, without entering into a thorough discussion of the possibilities and best methods of its use.

MISCELLANEOUS WORK.

The miscellaneous work done by this division during the past year has been of an exceedingly varied character.

Many samples of minerals, ores, clays, etc., were received for identification and valuation, and in most cases proved to be of little or no value. For example, persons finding a piece of rock with a few particles of pyrites embedded in it frequently would imagine they had found an ore containing a precious metal owing to the metallic luster and color of the pyrites; and the specimen would be forwarded to this Department for assay.

The following is a partial list of such samples as were analyzed, mere inspection, in very many cases, being sufficient to ascertain their value:

(1) Mineral sent by Burrel Laseter, Rule, Ark.: Calcite and pyrites; of no value.

(2) Mineral sent by James Randolph, Neverfail, Tenn.: Granitic rock with pyrites; no value.

(3) Mineral sent by Joseph Watson, Nelsonville, Tex.: Limestone; tested for phosphoric acid with negative results.

(4) Mineral sent by John Osborne, Flag Pond, Va.: Limonite, an iron ore of little commercial value.

(5) Sent by George Dugan, Kansas City, Mo.: Blue sandstone; unfit for building purposes owing to the presence of pyrites.

(6) Sent by G. W. Robinett, Flag Pond, Va.: Galena and limestone.

(7) Sent by J. A. G. Blackburn, War Eagle Mills, Ark.: Limestone.

(8) Sent by Frank Long, Fayetteville, Ark.: Pyrites in sandstone.

(9) Sent by Frank Long, Fayetteville, Ark.: Iron ore (Hematite).

(10) Sent by Frank Long, Fayetteville, Ark.: Manganese ore (Wad.).

(11) Sent by Frank Long, Fayetteville, Ark.: Pyrites.

(12) Sent by Frank Long, Fayetteville, Ark.: Epidote in quartz.

(13) Sent by Frank Long, Fayetteville, Ark.: Limestone.

(14) Sent by Frank Long, Fayetteville, Ark.: Pyrites partly oxidized.

(15) Sent by Frank Long, Fayetteville, Ark.: Limestone.

(16) Sent by Frank Long, Fayetteville, Ark.: Silicified wood.

(17) Sent by Lee Breeding, Springdale, Tenn.: Pyrites.

(18) Sent by Alex. Moseley, Buckingham Court-House, Va.: Gneiss, epidote, and biotite.

(19) Sent by William B. Stark, Meridian, Tex.: Pyrites.
(20) Sent by B. D. Carter, Flag Pond, Va.: Calcite.
(21) Sent by G. W. Buiter, Knapp, Pa.: Quartz.
(22) Sent by G. W. Kile, Upper Tract, W. Va.: Ferruginous clay.
(23) Sent by Frank P. Bond, Brownsville, Tenn.: A good quality of pottery clay, or suitable for the manufacture of brick.
(24) Sent by G. W. Merk, San Francisco, Cal.: Carbonate of lime and a trace of phosphoric acid.
(25) Sent by George W. Robinett, Flag Pond, Va.: Gypsum.
(26) Sent by George W. Robinett, Flag Pond, Va.: Oxide of iron.
(27) Sent by Daniel Bond, Brownsville, Tenn.: A clay of good quality for pottery and brick making, but not suitable for fire-brick.
(28) Sent by D. L. Chamberlin, Clearwater Harbor, Fla.: An inferior article of clay, containing a large amount of iron, sand, and gravel.
(29) Sent by J. A. Frogs, Harrison, Ark.: Iron ore (Hematite).
(30) Sent by J. A. Ragsdale, Gainesville, Tex.: A horseshoe incrusted with carbonate of lime and oxide of iron, caused by lying in water containing carbonates of lime.
(31, 32, 33, and 34) Sent by Henry W. Sturmer, Richlandtown, Pa.: Samples of rocks, none of which had any value.
(35) Sent by S. H. Hemmenway, Washington, D. C.: Manganese ore, containing also iron and phosphoric acid.
(36) Sent by W. W. Brown, Clinton County, Pa.: Mineral paint, ochre.
(37) Sent by E. E. Rope, Lake View, Fla.: Sulphate of lime (gypsum).
(38) Sent by O. W. Longan, Washington, D. C.: Sample of impure limestone.
(39) Sent by H. Rosenfeldt, Mimbres, Grant County, N. Mex.: Mountain cork: a variety of asbestos.
(40) Sent by C. S. Sterner, Cooperstown, Pa.: Supposed to contain lead or coal, but contained neither.
(41) Sent by H. Shrout, Menifee County, Ky.: Contained 14.84 per cent. phosphoric acid, and would make a valuable fertilizer when finely ground.
(42) Sent by G. S. Allen, Harrison, Ark.: Contains traces of copper and phosphoric acid.
(43, 44, 45, 46, 47, and 48) Sent by Hon. C. T. O'Ferrall, M. C.: Minerals composed of quartz and pyrites, the latter having been mistaken for gold. None of the samples are of any value.
(49) Sent by A. Y. Simpson, Elliott, Miss.: A sample of clay very free from iron, but containing too much soda and potash to make good fire-brick.
(50) Sent by J. Milton Moore, Richlandtown, Pa.: A mineral supposed to contain lead or tin, but found to contain neither.
(51) Sent by W. F. Combe, Hillam, Ind.: A mineral consisting largely of sulphide of zinc, and valuable as a zinc ore.
(52) Sent by A. M. Sloan, Valley Spring, Ark.: Contains particles of pyrites which were mistaken for gold.
(53) Sent by B. F. Reed, Mineola, Tex.: Galena, which might prove valuable as a source of lead.
(54) Sent by Hon. F. M. Cockrell, U. S. Senate: Minerals supposed to contain manganese, but none was found.
(55) Sent by Hon. F. G. Barry, M. C.: Supposed to contain silver. No silver was found, but some galena and sulphide of zinc.
(56) Sent by James W. Warne: Minerals consisting of silicates of iron, alumina, etc., and of no value.
(57) Sent by J. D. Tillett: Mineral supposed to contain tin: contains no tin, but consists largely of binoxide of manganese.
(58) Sent by W. S. Pridgeon: Supposed to be diamonds: found to be small crystals of quartz.
(59) Sent by Henry A. Bathurst, Cheyenne, Wyo.: A lump of slag, which sender thought contained tin; consists almost entirely of iron.

SAMPLES OF FERTILIZERS, FERTILIZING MATERIALS, MARLS, ETC.

(60) Sent by E. G. Watson, Baltimore, Md.: A marl, containing a small amount of phosphoric acid and a trace of potash, but not sufficient of either to make it a valuable fertilizer.
(61) Sent by Mrs. E. C. Joins, Madisonville, Tenn.: Brown earth, containing a large quantity of organic matter, but not enough to make it very valuabl eas a fertilizer.
(62) Sent from Van Opstal's vineyard, Spottsylvania, Va.: A fertilizer containing 2.63 per cent. phosphoric acid, and 4.94 per cent. of nitrogen.

(63) Sent by W. N. Reed: Green sand; contains a trace of lime and phosphoric acid; no value.

(64) Sent by Charles Metzner, Kewaunee, Wis.: Sample consisting of shell marl with a trace of phosphoric acid.

(65) Sent by Frank Banney, Farmdale, Ohio: A marl containing no phosphoric acid.

(66) Sent by Ohio State Board of Agriculture, Columbus, Ohio: Two samples of commercial fertilizer, serial Nos. 4958 and 4959; analyses as follows:

	4958.	4959.
	Per cent.	*Per cent.*
Total phosphoric acid	19.64	18.03
Soluble phosphoric acid	9.76	9.92
Reverted phosphoric acid	3.32	2.81
Insoluble phosphoric acid	3.34	2.15

(67) Sent by Fred. Sassur, jr., Marlborough, Md.: A marl containing a trace of phosphoric acid.

(68) Sent by S. H. Griffin, Saint Stephens, S. C.: Sample described as "bone;" contains only a trace of phosphoric acid.

(69) Sent by Louis Schade, Washington, D. C.: A clay supposed to contain phosphoric acid, but none was found.

(70) Samples sent by G. W. Knapp, Limona, Fla.: Serial Nos. 4983, 4984, and 4985. 4984 is a coprolite and a very valuable fertilizer:

No.	Phosphoric acid.
	Per cent.
4983	.2
4984	34.4
4985	1.6

(71) Sent by Daniel Moler, Moler, W. Va.: A blue slate supposed to contain phosphoric acid, only a trace of which was found.

(72) Sent by N. C. Nutting, Oswego, N. Y.: A marl containing no phosphoric acid.

(73) Sent by W. P. Hill, Lake George, Fla.: A marl containing a considerable quantity of phosphoric acid.

(74) Sent by S. H. Hemmengway, Wsahington, D. C.: A marl containing a trace of phosphoric acid.

(75) Sent by J. R. Dodge, Washington, D. C.: A marl tested for phosphoric acid.

(76) Sent by C. E. Pearson, Beach, Miss.: A shell marl tested for phosphoric acid.

(77) Sent by F. R. Evans, Washington, D. C.: A muck containing a large quantity of organic matter, but no phosphoric acid.

(78) Sent by Alonzo Thompson, Baltimore, Md.: Samples of phosphoric acid and phosphate of soda, serial Nos. 5297 and 5298:

No.	Phosphoric acid.
	Per cent.
5297	10.61
5298	18.25

(79) Sent by L. J. Kimbell, Gatesville, Tex.: Samples of bat guano, serial Nos 5193 and 5194; analyses as follows:

	5193.	5194.
	Per cent.	*Per cent.*
Phosphoric acid	.97	4.98
Ammonia	4.69	11.15

(80) Sent by D. A. Beard, Martinsburgh, W. Va.: Two samples commercial fertilizer, serial Nos. 5293 and 5296; analyses as follows:

No.	Sample.	Phosphoric acid.
		Per cent.
5293	S. C. dissolved rock	16.20
5296	Patapsco Company fertilizer	17.24

(81) Sent by C. E. Pearson, Beach, Miss.: A marl containing a trace of phosphoric acid.

(82) Sent by W. W. Cobey, Cross Roads, Md.: Three samples of marl, each containing a small amount of phosphoric acid.

(83) Sent by W. W. Watts, Collegeville, Ark.: A shell marl containing a trace of phosphoric acid.

(84) Sent by James D. Sherer, DeLand, Fla.: A fertilizer suspected of causing a diseased condition of orange trees. It contained 8.45 per cent. of phosphoric acid and 1.46 per cent. of nitrogen. This fertilizer does not appear to be of a nature to produce any deleterious effect upon orange trees, and the disease complained of is doubtless due to some other cause.

(85) Sent by committee on nitrogen of the Association of Official Agricultural Chemists: Six samples, in which the nitrogen was determined as indicated by the following table:

Number.	Soda lime method.	Kjeldahl method.	Ruffle method.	New Ruffle method.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
1	13.49	13.86	13.44	13.83
2	2.97	2.82	2.57	3.24
3	3.08	3.20	3.05	3.16
4			3.30	2.70
5			3.14	2.91
6			2.52	2.57

(86) Sent by committee on phosphoric acid of the Association of Official Agricultural Chemists: Five samples for the determination of phosphoric acid:

Number.	Moisture.	Total phosphoric acid.	Soluble phosphoric acid.	Insoluble phosphoric acid.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
1	.76	28.16		
2	6.44	14.23		
3	14.06	9.63	6.74	1.30
4	9.33	15.22	10.68	1.28
5	8.25	18.06	6.78	3.34

(87) Sent by committee on dairy products of the Association of Official Agricultural Chemists: Four samples of butter and butter substitutes:

Number.	Specific gravity.	Melting point.	Volatile acids, cubic centimeters, one-tenth alkali.	Saponification equivalent.	Water.	Salt.	Curd.
		°C.			*Per cent.*	*Per cent.*	*Per cent.*
1	.9060	31.8	.40	281.0	6.49	1.99	.34
2	.9046	40.1	.40	288.7	6.64	2.11	.58
3	.9091	34.5	13.06	244.0	8.97	4.56	.78
4	.9109	33.0	15.49	248.0	8.44	.79	.64

(88) Sent by the Commissioner of Internal Revenue: Two samples of butter suspected of being adulterated. The analyses show that these butters are genuine. A microscopic examination showed that they had been artificially melted:

Number.	Specific gravity.	Melting point.	Saponification equivalent.	Cubic centimeters, one-tenth normal alkali.	Salt.
		°C.			Per cent.
1	.91195	33.70	245.3	17.1	5.58
2	.91087	32.00	249.4	15.8	8.41

(89) Sent by E. M. Nesbit, Maythorpe Farm, College Station, Md.: Five samples of milk. The analyses showed that these milks contain about 1 per cent. more fat in proportion to the total solids than the ordinary milks of commerce:

Number.	Milk.	Fat.	Total Solids.
		Per cent.	Per cent.
1	Morning	4.14	12.71
2	Evening	4.16	12.25
3	Morning	4.22	11.55
4	Evening	....	11.89
5		4.87	12.80

(90) Sent by J. D. Johnson, Washington, D. C.: Sample of butter from Tennessee:

Specific gravity at 40° C	.908
Saponification equivalent	248.00
Cubic centimeters one-tenth normal alkali	15.12
Per cent. salt	1.42
Per cent. of moisture	10.25
Per cent of curd	.44

EXAMINATION OF LIGNITES, ETC., SUBMITTED AS SUITABLE MATERIALS FOR FILTERING SUGAR SOLUTIONS.

(91) Sent by R. A. Amdorf, Van Buren Furnace, Va.: Sample supposed to be coal or lignite, but which proved to be only a black shale.

(92) Sent by Courier-Journal Company, of Louisville, Ky.: A sample of lignite This sample possessed but little decolorizing power on a solution of molasses:

	Per cent.
Loss on ignition	92.70
Ash	7.30

(93) Sent from Avery's Island, La.: A sample of lignite. This sample possessed but little decolorizing power:

	Per cent.
Moisture	11.73
Volatile and combustible matter	49.50
Ash	38.74
Sulphur	.75

(94) Sent by Charles E. Pearson, Beach, Miss.: Sample of lignite. The soluble extract possessed an acid reaction, and the decolorizing power of the sample was very slight:

	Per cent.
Moisture	17.14
Ash	9.25
Soluble in water	4.56

(95) Sent by J. B. Friedheim, Camden, Ark.: Sample of lignite. This sample possessed a high decolorizing power:

	Per cent.
Moisture	30.18
Ash	6.89
Soluble in water	.34

(96) Sent by B. F. Reed, Mineola, Tex.: Sample of lignite. The aqueous extract had a very faint acid reaction. The filtration was rapid, but the decolorizing power not strongly marked:

	Per cent.
Moisture	24.76
Ash	5.65
Soluble in water	.36

(97) Sent by M. Swenson, Fort Scott, Kans.: Two samples of lignite. The aqueous extracts were faintly acid and the decolorizing power very slight:

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Moisture	8.29	13.71
Ash	30.25	5.04
Soluble in water	.52	.40

(98) Sent by the Hon. Commissioner of Agriculture: Sample of bituminous coal:

	Per cent.
Volatile matter	31.51
Coke	68.49
Ash	4.10

(99) Sent by Hon. Benton McMillin, of Tennessee: A sample from Carthage, Tenn., which proved to be graphite.

EXAMINATION OF SAMPLES OF WATER.

A large number of samples of water have been sent to this division for examination within the past year. As has already been intimated, the analysis of waters is not a work which falls within the legitimate scope of agricultural chemistry except in cases where its fitness or unfitness for the use of stock might be called in question. Nearly all the samples of water which have been received were sent on the supposition that they contained medicinal principles. Wherever it has been possible to do so the analysis of these samples has been declined. When an examination has been made it has been of

the simplest nature possible. The force of chemists employed in the division was so small as to render it impossible to make complete analyses of the samples examined.

(100) Sent by F. P. Bishof, Washington, D. C.: A mineral water containing large quantities of solid matter:

Grains of solid matter per gallon	391. 3

(101) Sent by F. P. Bishof, Washington, D. C.: Mineral water containing a very large quantity of solid matter:

Grains of solid matter per gallon	1,184. 6

(102) Sent by Philip Walker, Washington, D. C.: A sample of water from Newton, Kans., water-works:

Grains of solid matter per gallon	47. 587

This is too large a quantity for good potable water.

(103) Sent by H. S. Alexander, Culpeper, Va.:

Grains solid matter per gallon	26. 243

(104) Sent by J. C. Rounds, Manassas, Va.: Two samples of potable water:

No. 1, well water, grains solid matter per gallon	14. 580
No. 2, spring water, grains solid matter per gallon	4. 665

Sample of spring water is very good. The well water is rather hard.

(105) Sent by Stephen Gill, Washington, D. C.: Sample of pump water from city pump.

Grains solid matter	per gallon	56. 918
Grains chlorine	do	29. 936
Free ammonia	parts per 100,000	115
Albuminoid ammonia	do	66

This water is totally unfit for domestic purposes, and shows how easily well waters in a city become contaminated.

(106) Sent by James P. Stabler, Sandy Springs, Md.: Sample of potable water:

Grains solid matter	per gallon	4. 899
Free ammonia	parts per 100,000	1. 2
Albuminoid ammonia	do	6. 6

This is a very pure water.

(107) Sent by O. Hendricks, Marshall, Tex.: Two samples of supposed mineral water:

No. 1, grains solid matter	per gallon	11. 664
No. 2, grains solid matter	do	6. 415

Sample No. 1 contains slight amount of iron, and sample No. 2 gave indications of having contained hydro-sulphuric acid when fresh.

(108) Sent by S. H. Hemenway, Chicago, Ill.: Sample of supposed mineral water:

Grains solid matter per gallon	6. 943

This sample contains no constituents of a medicinal nature.

(109) Sent by John P. Horan, Shreveport, La.: A sample of mineral water:

Grains solid matter	per gallon	312. 44
Free ammonia	parts per 1,000,000	. 67
Albuminoid ammonia	do	3. 24

(110) Sent by William M. Gatewood, Carrizo Springs, Tex.:

Grains solid matter	per gallon	1,396. 3

The solid matter consists of lime, magnesia, alumina, soda, potash, and traces of iron combined as sulphates, chlorides, and carbonates. It also contains free ammonia, parts per million, . 026; albuminoid ammonia, parts per million, . 320.

(111) Sent by Peter Morong, Virginia: Three samples of potable water:

No. 1, grains solid matter	per gallon	7. 581
No. 2, grains solid matter	do	6. 377
No. 3, grains solid matter	do	7. 420

These are all good waters.

MISCELLANEOUS EXAMINATIONS OF FOOD PRODUCTS.

(112) Sent by M. J. Martinez, New York City: Three samples of Cuban sugar-cane:

No.	Cane.	Sucrose.	Sucrose by inversion.	Glucose.
		Per cent.	*Per cent.*	*Per cent.*
1....	Ten months old............	20.6	20.75	.98
2....	Eleven months old	13.0	16.9	3.39
3....	Fourth year stubble........	18.3	18.4	.93

The above percentages are given for the juice. The first and second sets of numbers should be diminished by 10 per cent. and the third by 12 per cent. when calculated for the cane itself.

(113) Sent by Col. F. E. Boyd, Delta, Colo.: A sample of sorghum sirup:

Specific gravity		1.417
Sucrose	per cent..	39.30
Glucose	do	28.73
Ash	do	3.94
Other solids not sugar	do	3.97
Co-efficient of purity		49.50

(114) Sent by James M. Hart, Oswego, N. Y.: Sample of sugar beets:

In whole beet:		
Moisture	per cent..	76.90
Ash	do	.92
In the juice:		
Specific gravity..		1.070
Total solid matter	per cent..	16.76
Sucrose	do	12.63
Glucose	do	.30
Co-efficient of purity		75.40

Presence of glucose in the juice of the beet is probably due to the fact that a considerable time elapsed after the beet was harvested before the analysis was made.

(115) Sent by Seth H. Kenney, Morristown, Minn.: A sample of sorghum sirup:

Specific gravity		1.3965
Sucrose	per cent..	40.45
Glucose	do	23.43
Co-efficient of purity		52.53

(116) Sent by Densmore Brothers, Red Wing, Minn.: Sample of sorghum *masse cuite*:

Sucrose	per cent..	46.30
Sucrose by inversion	do....	49.16
Glucose	do....	30.40

(117) Sent by Henry McCall, Donaldsonville, La.: Sample of sugar-cane molasses from second crystallization:

Sucrose	per cent..	29.00
Glucose	do....	22.00

(118) Sent by Capt. S. S. Blackford, Washington, D. C.: Sample of maple sirup from Ohio:

Sucrose	per cent..	60.10
Sucrose by inversion	do....	61.30
Moisture	do....	35.24
Glucose	do....	.96
Ash	do....	4.03
Acidity as acetic acid	do....	.11

(119) Sent by Lewis F. Ware, Philadelphia, Pa.: Two samples of dates:

No.	Sucrose.	Glucose.
	Per cent.	*Per cent.*
1	5.05	41.8
2	4.68	42.4

(120) Sent by Sheldon E. Elderkin, Cooperstown, N. Y.: A sample of maple sugar:

Sucrose	per cent..	77.60
Sucrose by inversion	do....	79.76
Moisture	do....	15.33
Glucose	do....	3.92
Ash	do....	.85

(121) Sent by W. J. Thompson, Pattersonville, La.: Sample of sugar-cane molasses from second crystallization:

Sucrose	per cent..	33.70
Sucrose by inversion	do....	41.00
Glucose	do....	27.00

(122) Sent by Springer Harbaugh, Saint Paul, Minn.: One sample of wheat and one of barley:

	Wheat.	Barley.
Weight per bushel ....pounds..	62.7	65.4
Weight of 100 grains........grams..	2.233	3.755
Moisture ....per cent..	6.52	7.52
Ash ....do....	1.48	1.44
Fat ....do....	2.52	3.55
Carbohydrates ....do....	71.93	72.77
Crude fiber ....do....	2.06	2.12
Albuminoids ....do....	15.49	12.60

(123) Sent by A. Chandler, Fargo, Dak.: A sample of Polish wheat:

Moisture	per cent..	8.82
Ash	do....	1.89
Oil	do....	2.60
Carbohydrates	do....	67.92
Crude fiber	do....	1.33
Albuminoids	do....	17.42

(124) Sent by W. T. Kelso, Hallock, Minn.: A sample of wheat:

Weight per bushel	pounds..	67.00
Weight of 100 grains	grams..	2.925
Moisture	per cent..	7.58
Ash	do....	1.45
Oil	do....	3.65
Carbohydrates	do....	70.59
Crude fiber	do....	1.68
Albuminoids	do....	15.05

(125) Sent by L. H. Haines, Fargo, Dak.: A sample of wheat:

Moisture	per cent..	7.80
Ash	do....	1.77
Crude fiber	do....	1.70
Albuminoids	do....	15.93
Carbohydrates	do....	72.80

(126) Sent by W. H. Reed, Walla Walla, Wash.: A sample of wheat:

Moisture	per cent..	7.42
Ash	do....	1.95
Oil	do....	1.98
Crude fiber	do....	2.13
Albuminoids	do....	9.89
Carbohydrates	do....	76.63

(127) Sent by Alex. McBeth, Georgetown, D. C.: Sample of rice husks and ash from same:

Organic matter in husks	per cent..	81.72
Moisture in husks	do....	4.15
Ash in husks	do....	14.13
Silica in ash	do....	89.13

The ash also contains a trace of manganese.

(128) Sent by J. H. Watkins, Palmetto, Ga.: A sample of Kaffir corn:

Moisture	per cent..	11.18
Ash	do....	1.22
Oil	do....	3.58
Dextrine	do....	3.37
Sugars	do....	1.85
Starch	do....	67.62
Albuminoids	do....	9.73
Crude fiber	do....	.85

(129) Sent by W. M. King, superintendent Seed Division.: A sample of Kaffir corn for the determination of nitrogen only:

Nitrogen	per cent..	1.43
Equal to albuminoids	do....	8.93

(130) Sent by William M. Singerly, Philadelphia, Pa.: A sample of brewer's grain:

Moisture	per cent..	7.86
Ash	do....	4.33
Oil	do....	5.66
Carbohydrates	do....	51.37
Crude fiber	do....	8.81
Albuminoids	do....	21.97

(131) Sent by John A. Baker, Washington, D. C.: A sample of pea-meal:

Moisture	per cent..	8.21
Ash	do....	3.73
Oil	do....	1.89
Carbohydrates	do....	62.16
Crude fiber	do....	2.19
Albuminoids	do....	21.82

This meal would make an excellent cattle food, having a very high percentage of nitrogenous matters, with a good proportion of phosphoric acid in the ash.

(132) Sent by Dr. W. M. Mew, Washington, D. C.: A sample of food material for the determination of nitrogen only:

Nitrogen	per cent..	4.75
Equal to albuminoids	do....	29.75

(133) Sent by J. Sears, Chicago, Ill.: A sample of cotton-seed hulls for the determination of nitrogen only:

Nitrogen	per cent..	.77
Equal to ammonia	do....	.93

(134) Sent by J. Sears, Chicago, Ill.: A sample of powdered olive stones for the determination of nitrogen only:

Nitrogen	per cent..	.25
Equal to albuminoids	do....	1.56

(135) Sent by J. Sears, Chicago, Ill.: Powdered cocoa-nut shells for the determination of nitrogen only:

Nitrogen	per cent..	.20
Equal to albuminoids	do....	1.25

(136) Sent by the Hon. Secretary of the Treasury: A sample of opium from the collector of customs at San Francisco:

Moisture	per cent..	21.10
Morphia	do....	6.38

(137) Sent by Ernest T. Gennert, Berlin, Germany: Two samples of cotton-seed meal, in one of which the oil had been extracted by hydraulic pressure and the other by petroleum:

	Hydraulic pressure.	Petroleum.
	Per cent.	*Per cent.*
Moisture	6.10	7.52
Ash	7.50	6.35
Crude fiber	2.99	12.01
Nitrogen	7.47	5.29
Equal to albuminoids	46.69	33.06
Oil	13.26	3.27

(138) Sent by Dr. George Vasey, botanist: A sample of tiquila, a fermented liquor made from fermented agaves:

Alcohol	per cent..	41.58
Dry residue	do	.012
Aromatic oil	do	.020

This liquor has a slight acid reaction and contains no fusel oil.

H. W. WILEY,
Chemist.

HON. NORMAN J. COLMAN,
Commissioner of Agriculture.

REPORT OF THE BOTANIST.

SIR: The subjects which have largely occupied the attention of this division during the past year are—

First. An investigation of the grasses of the arid districts of the West and Southwest, concerning which a bulletin has been published. Two agents were employed in the examination in western Texas, New Mexico, Arizona, and parts of Nevada and Utah. Some two hundred species of grasses were observed growing in different situations and soils, and about thirty of these have been selected as deserving of attention and experiment for purposes of cultivation. Figures and descriptions of these are given in the bulletin in order to facilitate an acquaintance with them by persons interested, and it is hoped that a careful trial will be made of such by the farmers and graziers of the district.

Second. Several new or interesting and promising forage plants have been brought to the attention of the Department as presenting promising features for cultivation in special localities. Among these are some species of clover, and a European forage plant known as Sainfoin or Asperset (botanically, *Onobrychis sativa*), which has attracted, recently, considerable attention in California and Nevada as giving promise of great value for cultivation on dry hills and mountain slopes.

A paper on *Teosinte* as a forage grass is also presented. On account of the large quantity of foliage which this grass affords, it has great value for soiling and storing in silos wherever the climate will allow of its full development.

Third. We have continued an account of common weeds which interfere with agriculture, and have given such information respecting their destruction and eradication as we have been able to obtain. In addition, some account is given of the cultivation of Peppermint for the purpose of procuring the oil for medicinal and pharmaceutical purposes.

A paper on cross-fertilization and another on pollination are also presented, which will provoke research and investigation.

Respectfully,

GEO. VASEY,
Botanist.

Hon. N. J. COLMAN.

FORAGE PLANTS.

TEOSINTE (*Euchlæna luxurians*).

This new forage plant, a native of Central America, bids fair to fill a permanent place for the South. Seed was first introduced into this country by the Department many years ago, but not until 1886 is there any record of its having ripened seed in the United States. In that year a small quantity was ripened in southern Florida and

in southern Mississippi, near the Gulf. In the fall of 1887 circulars were sent to a number of parties to whom seed had been distributed the preceding spring, asking whether any of the plants had ripened seed; also that samples of the growth be sent to the Department. Samples bearing ripe seed were received from several parties in southern Florida, but from no other locality. On one of the stalks, having 13 fertile joints, 812 seeds were counted. In some cases ripe seed was produced on plants the seed of which was planted the preceding spring, but usually it was produced on those the roots of which had lived through the previous winter, Teosinte having been cultivated for a number of years in that section. A quantity of the crop of seed which ripened in southern Florida the past season has been purchased by the Department to be distributed in the spring of 1888.

Teosinte makes a rapid, succulent, and abundant growth, which, in the warmer parts of the country, may be cut two or more times during the season. In Florida the first crop from roots which have lived over winter is sometimes cut for fodder, and the second crop left to ripen seed. This plant requires good soil, and that which is moist but not necessarily wet. It can not be considered of any value for the dry regions of the West, except where irrigation is practiced. It seems to suffer from the effects of drought rather more than Indian corn. On good soil which is not too dry it will probably prove to be of value much farther north than where it attains its complete development. On good garden soil on the Department grounds plants from seed sown on the 4th of last June attained a height of 6 feet by the 29th of July.

A sample of Teosinte grown in 1885 by John S. Erwin, of Kirkville, Mo., was analyzed by Mr. Edgar Richards, of the Chemical Division of this Department, and found to contain a lower percentage of crude fiber and a higher percentage of albuminoids than either clover or timothy hay. Mr. Clifford Richardson, the acting Chemist, expressed the opinion, however, that the sample was exceptionally rich. (Plate I.)

WHITE SAGE (*Eurotia lanata*).

This plant, known as "White Sage" or "Winter Fat," is abundant in places through the Rocky Mountain region from Mexico to British America. Prof. S. M. Tracy, who visited portions of Nevada, Arizona, and adjoining territory in 1887, investigating the native forage plants under the direction of the Commissioner of Agriculture, states that in more arid districts of Arizona, Nevada, and Utah this plant, with Greasewood (*Sarcobatus vermiculatus*), are the most highly valued plants for winter forage. An important fact in regard to the plant is its ability to thrive in somewhat alkaline soils. It is employed as a remedy for intermittent fevers.

It is a perennial, half shrubby plant growing a foot or two high, with slender wooly twigs, which are abundantly covered with linear sessile leaves an inch to an inch and a half long, with a velvety surface of a grayish color and with the margin rolled back. They are mostly in small fascicles or clusters. The flowers are minute and in small clusters in the axils of the leaves, chiefly on the upper part of the stem. The flowers are of two kinds, male and female, on separate parts of the stems, or sometimes on separate plants. The small fruit is covered with long and close whitish hairs.

The plant belongs to the order *Chenopodiaceæ*, or the same order as the common Pigweed. (Plate II.)

Nopal or Cactus (*Opuntia Engelmanni*).

One of the principal characteristics of the vegetation of arid districts is the prevalence of different species of *Cactaceæ*, or cactus-like plants. These are exceedingly variable in form and size, and are divided into several genera. Of these the Opuntias are extremely common. There are two kinds of these; one with broad, flat joints, and one with cylindrical or club-shaped joints.

Of the flat, broad-jointed kind there are many species. The *Opuntia vulgaris* is common in sandy ground in the Eastern Atlantic States. In western Texas and other parts of the arid regions reaching to California is a much larger kind, of the same general appearance, which is called *Opuntia Engelmanni*. This is a stout, coarse-looking plant, growing from 4 to 6 feet high, and much branched. The joints are, in large specimens, a foot long and 9 or 10 inches broad, with groups of stout spines from one-half to 1½ inches long. They are apparently leafless, but in young specimens minute fleshy leaves may be detected. Springing from the side of these joints at the proper season are handsome flowers 2 or 3 inches in diameter, which are succeeded by a roundish fruit, nearly 2 inches long, filled with a purplish pulp, generally of an insipid taste, while imbedded in the pulp are numbers of hard, small seeds. The common name of this Opuntia among the Mexicans is Nopal, and some of the species have fruit which is edible and highly esteemed. The use of the above species of Prickly Pear or Cactus for forage in the dry regions of Texas and westward is a matter of considerable importance. An extended account of its use is given in Bulletin 3 of this division. The usual method of preparing the plant for feeding is to singe the prickles over a brisk blaze. To some extent, especially by sheep, the plant is eaten in the natural state, but serious consequences frequently result in such cases. Its chief use is as a substitute for other fodder in times of scarcity, but when properly prepared and fed with hay and grain it forms a valuable article of food for cattle. (Plate III.)

Sainfoin (*Onobrychis sativa*, Lam.).

This leguminous forage plant has recently been introduced into this country under the name of "Asperset."

Esparsette is the German name; Sainfoin is the name used in France and England. It is a perennial, having somewhat the appearance of Lucerne, but of smaller size and different habit. It seldom exceeds 1½ feet in height, with a weak stem, rather long, pinnate leaves, and flowers of a pink color in a loose spike, 2 to 4 inches in length, raised on a long, naked peduncle or stalk. The flowers are succeeded by short, single-seeded pods, which are strongly reticulated or marked by raised lines and depressed pits. It is a native of central and southern Europe and western Asia, and in Europe has long been in cultivation. From experiments made by the Duke of Bedford in England we learn that it was first introduced to English farmers as a plant for cultivation from Flanders and France, where it has been long cultivated. It was found to be less productive than the broad-leaved clovers, but on chalky and gravelly soils there was abundant proof of the superiority of Sainfoin. It produces but little herbage the first year, but improves in quantity for several years.

Mr. Martin J. Sutton, in a recent work on "Permanent and temporary pastures," says that it has been cultivated in England for over two hundred years. He says that it is essentially a food for sheep, and in pasturing the sheep do it no injury. It is also useful for horses, but produces nothing like the quantity of green fodder that can be obtained from the Lucerne patch. When sown alone Mr. Sutton says that Sainfoin is liable to decrease and become overrun with weeds. He recommends its use as a predominant constituent in a mixture of grasses and clovers. He says that combined with strong growing grasses there is less risk and the grasses keep down the weeds which otherwise are apt to overrun the Sainfoin. In a green state it is quite free from the danger of blowing cattle (Hoven), and when made into hay is an admirable and nutritious food. But it requires great care in drying when made into hay.

Mr. Sinclair states that the produce of Sainfoin on a clayey loam with a sandy subsoil is greater than on a sandy or gravelly soil resting upon clay.

A French writer says that Sainfoin can not accommodate itself to damp soil, and even dreads soil which, although dry, rests upon a wet subsoil. It delights in dry soil, somewhat gravelly and, above all, calcareous. It flourishes upon the declivities of hills where water can not remain, and in light soil where its powerful root can readily penetrate. But, although surviving in the poorest calcareous soil, like clover and Lucerne, its productiveness is always relative to the permeability and fertility of the land. It prefers open, sunny places, with a southern or eastern exposure.

Sainfoin has received several trials in this country, but without much success, probably from the experiments having been made upon unsuitable soil. We can not expect that it will be preferred in places where clover succeeds, but in light soils and in regions with a light rain-fall it should receive a thorough trial.

A recent bulletin of the Iowa Agricultural College gives the result of some experiments with this plant, which are very satisfactory. Observations there made indicate that it stands early freezing quite as well as Kentucky blue-grass. It produces at the rate of 3 tons of dry hay per acre. It deserves trial in Kansas, Nebraska, and Colorado. (Plate IV.)

ALSIKE CLOVER (*Trifolium hybridum*, L.).

This differs from common red clover in being later, taller, more slender and succulent. The flower heads are upon long pedicels, and are intermediate in size and color between those of white and red clover. Its botanical name was so given from its being supposed by Linnæus to be a hybrid between those clovers, but it is now known to be a distinct species. It is found native over a large part of Europe, and was first cultivated in Sweden, deriving its common name from the village of Syke in that country. In 1834 it was taken to England, and in 1854 to Germany, where it is largely grown, not only for its excellent forage but also for its seed, which commands a high price. In France it is little grown as yet, and is frequently confounded with the less productive *Trifolium elegans*.

The following is condensed from "Les Prairies Artificielles" by Ed. Vianne, of Paris:

Alsike does not attain its full development under two or three years, and should therefore be mixed with some other plant for permanent meadows. It is best adapted to cool, damp, calcareous soil, and gives good results upon reclaimed marshes.

It is adapted neither to very dry soils nor to those where there is stagnant water. Being of slender growth, rye-grass, rye, or oats are often sown with it, when it is to be mowed. In fertile ground weeds are apt to diminish the yield after a few years, so that it requires to be broken up. It is generally sown in May, at the rate of 6 to 7 pounds of the clean seed per acre. Sometimes it is sown in the pods at the rate of 50 to 100 pounds per acre either in spring or in autumn after the cereals are harvested.

Alsike sprouts but little after cutting, and therefore produces but one crop and one pasturage. The yield of seed is usually 130 to 170 pounds per acre. The seed separates more easily from the pods than that of ordinary clover, and as the heads easily break off when dry, care is required in harvesting.

It does not endure drought as well as the common red clover, but will grow on more damp and heavy soils, and it is said that it can be grown on land which, through long cultivation of the common clover, has become "clover sick."

(Plate V.)

FRENCH CLOVER (*Trifolium incarnatum*).

This annual clover is a native of Europe. It grows to the height of about 2 feet. The heads are about 2 inches long, very densely flowered, with the petals varying from a pinkish to a crimson color.

It has been introduced and tried to some extent for cultivation in this country, but has not met with much favor. It deserves trial, however, in the dry climate of the West. (Plate XIV.)

MAMMOTH CLOVER (*Trifolium medium*).

The true botanical position of the clovers cultivated in this country under the names Mammoth, Sapling, or Pea-vine clover, etc., is still somewhat in doubt. They are usually regarded as being the above-mentioned species, but are, perhaps, a variety or varieties of the common red clover, *Trifolium pratense.* They agree in having a larger and later growth than the ordinary red clover, and on this account are for some purposes more valuable.

The following records of experience may be relied upon for the localities mentioned:

Prof. Samuel Johnson, Agricultural College, Michigan:

It grows too rank and coarse to make good hay. For pasture or for manurial purposes it might prove better than the smaller sort. When grown for seed it is usually pastured until the 1st of June, and then allowed to grow up and mature the crop.

M. C. Alger, Augusta, Mich.:

Pasturing until the 1st of June insures a larger yield of seed, as it is cooler while filling; but many do not pasture. I do not think it can be cut more years than the smaller kind. It is said to stand drought better, but I doubt that. It will give three times the amount of pasture during the season that is given of the smaller kind if kept down pretty close, but during the fall the amount of pasture produced is less. It is said to smother out in winter if a large amount is left on the ground. Another objection is that it requires cutting just at harvest time.

C. M. Alger, Newaygo, Mich.:

I have raised the Mammoth Clover, but do not like it for my heavy land, as it grows too large. For every acre that I raise I have to buy or borrow two more of my neighbor's to cure it on. It is, however, excellent for pasture, as it stays on the ground longer than the medium variety. It is good for raising seed, as it nearly always fills full. I have seen 8 bushels per acre. The seed is always grown on the first crop, as the second never blossoms. It grows here from 4 to 5 feet high and is good for plowing under for manure.

Austin Pots, Galesburgh, Mich.:

Perhaps not over 20 per cent. of the clover grown here is of the mammoth variety. It does not seed as well as the common clover.

L. H. Bursley, Jenisonville, Mich.:

I do not find it as good for hay as the common red clover: the stalk is so large that stock will not eat them at all. For pasture it is better than the small variety. It does not require pasturing in spring in order to produce a crop of seed.

James Hendricks, Albany, N. Y.:

About twenty years ago there was treble the quantity sown in this part of Albany County that there is at present; now nearly all our farmers sow the medium clover with timothy.

Prof. F. A. Gully, Agricultural College, Miss.:

On good land with us it grows rank, and the long stems fall down and mat on the ground, and if we happen to have wet weather the lower leaves and parts of the stalk will begin to decay before the plant is in full bloom. The second crop ripens seed, but to what extent I can not say. I consider the common red clover more desirable here, although it may not yield as well.

WEEDS OF AGRICULTURE.

The following account of the more troublesome weeds is continued from the report of last year:

PURSLANE (*Portulaca oleracea*).

A low prostrate annual, common in cultivated grounds, with thick, fleshy, obovate leaves, about an inch in length, and very smooth. The flowers are minute and sessile at the ends of the branches and in the axils of the leaves, opening only in the morning sun; the five or six petals are pale yellow, the stamens number seven to ten and twelve, and the capsule or seed vessel is oval, and opens by the rupture of a transverse seam near the middle. This introduced weed is everywhere known in this country by the name of Purslane or "Pusley."

In the cooler climate of England it is not considered a weed, and is used to some extent as a pot-herb. It does not start into growth until the season is well advanced, in the Northern States about July. It is most troublesome in garden crops, such as onions, and does comparatively little harm in such crops as corn and potatoes, which shade the ground and permit horse cultivation. It is most prevalent on sandy soils. Its troublesomeness results mainly from its prolificacy and rapid maturity, and from the fact that it will retain its vitality and mature its seed after being detached from the soil. If the land is repeatedly cultivated before the plant exceeds an inch in height it is easily kept down, but if allowed to become large it is almost certain to ripen its seed. After garden soil has become stocked with the seed it will often be found best to cultivate the land in some field crop for two or three years, until it is freed from the weed, and grow the garden crops upon land which has not yet become infested.

The amount of seed produced may be judged from the fact that 1,250,000 seeds have been counted on a single plant. The greatest injury from this weed arises from the fact that it grows rapidly and ripens its seed after cultivation of the crops has usually ceased. (Plate VI.)

Common milkweed (*Asclepias cornuti*).

An herbaceous plant with a perennial root, native of this country, although now spontaneous in many parts of Europe. The stems are erect and unbranched 2 or 3 feet high, and clothed with opposite oblong leaves, with very short stalks, 4 or 6 inches long and with entire margins, soft and velvety on the lower side, with many prominent veins at right angles with the midrib, and connecting near the margin. The flowers are in large clusters, called umbels, proceeding from the top and upper portion of the stem, each umbel supported on a thickish peduncle 2 to 4 inches in length. The individual flowers, 20 to 40 in each cluster, are supported on slender pedicels about an inch in length. The flowers are less than half an inch long and of the peculiar structure common to the milkweed family. This will be best explained by reference to the figure given. Usually only one or two of these flowers mature fruit, which is an ovate pod about 3 inches long and an inch thick, roughish, with weak protuberances, but soft and velvety, and filled with a multitude of small flat overlapping seeds, each with a crown of soft silky fibers, which seems to waft the seed in the air.

This best known of our milkweeds, north of Tennessee and east of the Mississippi, has become exceedingly troublesome in some localities as a weed. Its deep running perennial root-stocks are very tenacious of life, and spread rapidly, throwing up numerous stems. The plant is most troublesome in meadows and along roadsides, forming patches which check the growth of grass. Its seeds are distributed by means of a tuft of silky hairs. The milky juice is a popular remedy with children for warts. The young shoots are used by some as a substitute for asparagus. The plant has a strong fiber, which some have attempted to utilize.

This plant is subject in some localities to the attacks of a fungus, which checks its growth and gives it a sickly yellow appearance. The affected leaves usually become revolute at the margin, and the plants, if badly affected, fail to blossom, and send up numerous slender shoots, reminding one of the "yellows" in peaches. The extermination of the plant requires careful cultivation throughout the entire season, after which it will not be found difficult to prevent its becoming again established. (Plate VII.)

Cursed crowfoot (*Ranunculus sceleratus*).

A low herbaceous plant of the Buttercup family with a smooth, thickish, spongy stem, much branched above. The lower leaves are one-half inch in diameter, deeply three-lobed, with the lobes coarsely and obtusely toothed; the upper leaves become narrower and less divided, or almost linear and undivided. The flowers are very numerous and small, on pedicels half an inch to an inch in length. The light yellow petals are less than one-fourth inch in length. The heads of carpels or fruit are, when mature, about half an inch long, densely crowded with the minute seeds. The plant attains a height of a foot or two. It is a native of Europe, but has been widely distributed over the world. It is found mainly in ditches and other wet places. The name was not given by reason of any extreme troublesomeness as a weed, but on account of the acrid and biting character of the juice. This is so irritating that if applied to the skin it will readily produce blisters. Notwithstanding this fact, if

the plant be boiled and the water thrown off, it is not unwholesome, and is sometimes eaten by the peasants in Germany as a vegetable. (Plate VIII.)

Chondrilla juncea.

This plant grows to the height of 2 or 3 feet, having strong, deeply spreading roots, and slender, twig-like stems, more or less branching above and apparently destitute of leaves, or with a few slender thread-like leaves. The leaves are mostly in a cluster at the base of the stem, where they have an irregular jagged shape, much like those of the Dandelion. The bare twigs become sparingly clothed during the summer with sessile flowers of the order *Compositæ;* in appearance much like those of Lettuce. This unsightly perennial weed has been introduced into Maryland, Virginia, and other Southern States, where it is spreading along roadsides and over dry uncultivated fields. Complaints have been received from Virginia of its agressive nature, and of the difficulty of its extermination. It is a native of the southern half of Europe and the adjoining countries of Asia. Over most of France it is common upon sandy soils. It has not yet entered England and the other northern countries of Europe, and therefore it is not expected that it will become prevalent to any extent in our Northern States.

For the eradication of this pest summer fallowing with frequent plowing and harrowing will be necessary. This method, succeeded by a hoed crop, will probably relieve the field of its presence. At the same time the greatest care should be taken to exterminate it from roadsides and neglected fields, where it is liable to maintain a foothold. (Plate IX.)

ST. JOHN'S WORT (*Hypericum perforatum*).

A perennial herb, growing 1½ to 2 feet high, usually with many opposite spreading branches, and clothed with many opposite, small, sessile leaves, less than an inch long, oblong or ovate-oblong, with entire margin and obtuse summit. These leaves are marked by many minute pellucid dots. The flowers are collected into small clusters or cymes at the extremity of the branches. They are less than an inch in diameter, with five deep yellow petals, which are twice as long as the lanceolate sepals. The stamens are very numerous, collected in several clusters. There are three pistils, which develop into a three-celled many-seeded pod.

This plant received its name, probably, from the fact that "the common people of France and Germany gather it with great ceremony upon St. John's day and hang it in their windows as a charm against storms, thunder, and evil spirits." The plant has been introduced and become naturalized quite extensively in this country east of the Mississippi. It is a perennial weed, rather troublesome in old fields and pastures. At one time it was supposed to cause ulcers upon the feet of cattle, but it has probably no such effect. (Plate X.)

PIGWEED (*Amarantus hybridus*).

This coarse annual weed, common in nearly all cultivated ground, grows to the height of 4 or 5 feet, with a much-branched stem, with numerous alternate leaves, which are mostly from 2 to 3 inches long,

of an ovate form, with prominent nerves and entire margins. The flowers are small, of a pale-green color, and very numerous in terminal and lateral spikes. Each minute flower has at the base three stiff, pungent bracts, with five thin, chaffy sepals, five stamens shorter than the sepals, and a central ovary or seed vessel containing a solitary black and shining seed. In some cases these flowers contain only stamens, and in others only the pistillate organs. The "Lamb's Quarters" or Goosefoot (*Chenopodium album*) is also known in common language as Pigweed. In some sections it is conveniently distinguished from that weed by the appropriate name of "Red Root."

The species here described and illustrated seems to be the one most abundant in cultivated grounds in this country. Like the other closely-related species which have become weeds, it is an introduction from the warmer parts of America or from Europe.

It is found abundantly native in Mexico and throughout the southern borders of the United States.

In Mexico and southern California the Amaranths are often used as forage plants, and the seed is gathered by the Indians for making bread. (Plate XI.)

Wild carrot (*Daucus carota*).

This biennial vegetable is so well known in its cultivated state in gardens as to hardly need any special description. It belongs to the Order *Umbelliferæ*, which is distinguished by having its small flowers in clusters, called umbels, so named because the flower stalks all start from one point at the extremity of a branch and spread out like the ribs of an umbrella. These stalks or rays, as they are called, are in most species again divided into smaller umbels called umbellets. In the Carrot these rays are very numerous, and form together a close flat-topped cluster, becoming concave in fruit. The leaves are divided and subdivided into numerous fine segments.

The Wild Carrot is abundant in several of the Central and Eastern States, and is spreading into new localities. It is not troublesome in cultivated land, being confined chiefly to meadows and roadsides. It is usually introduced in grass or clover seed. The umbels curl up when ripe and hold the seed into the winter, when it is gradually scattered ; sometimes the umbels break off and are driven over the snow, carrying the seeds to adjoining fields. Fifty thousand seeds have been counted on a plant of average size. Carefully cutting the plants for two years will eradicate most of them. (Plate XII.)

Coco or nut-grass (*Cyperus rotundus*, var. *Hydra*).

This so-called grass, a species of Cyperus or Sedge, is regarded as the worst pest of agriculture upon sandy soils throughout the South. It is said to have been accidentally brought to this country by a gentleman of New Orleans among some exotics obtained from Cuba. Thinking that he had obtained some rare plant he set it in his garden and thus introduced this terrible scourge. It produces but little seed, but propogates itself mainly by runners which ramify through the soil, producing tubers at intervals of 6 or 8 inches and sending up stems to the surface. It is exceedingly tenacious of life and ordinary plowing and cultivation serves only to make it spread more rapidly. "The only process yet discovered by which this grass

can be extirpated is to plow or hoe the spots in which it grows every day through the whole season. In their perpetual efforts to throw their leaves to the light the roots become exhausted and perish."

It is said also that by planting the land to Bermuda grass the Nut-grass may be smothered out. Its appearance is well represented in the figure.

A correspondent of the Times-Democrat thus describes his experience with this pest:

I had a few acres thickly infested with nut-grass and determined, if possible, to get rid of this unwelcome interloper. Broke the land deeply in the fall, gave it a shallow plowing the following spring, and planted in cotton early in April. I cultivated it as well as I could, but it seemed almost impossible to keep ahead of the grass. About August 15, I took the turning plow, wrapped the grass up completely, and did not allow it to go to seed. I can not explain how it is, but my coco has disappeared and I am troubled with it no longer.

(Plate XIII.)

BARBERRY (*Berberis vulgaris*).

This shrub is a native of Europe, but has been introduced into the United States; is frequently seen in cultivation, and in New England has in some places escaped and become wild. It is a pretty ornamental shrub, attaining a height of 8 to 10 feet. The twigs are commonly spiny, and the leaves, which are obovate and sharply toothed on the margins, are in fascicles in close connection with the spines. The flowers are in racemes, like those of the currant, are of a yellow color, and are succeeded by bright red, oblong, acid berries. The berries are often used in making preserves for the table.

The shrub is brought to notice, not because it has yet become so common as to be called a weed, but principally because of the common but fallacious belief among farmers that the presence of this bush was the cause of rust in grain. This opinion arose from the fact that the leaves of the Barberry are subject to the attack of a fungus which is identical with one of the stages of the wheat rust, but has no necessary connection with it. (Plate XV).

MEDICINAL PLANTS.

PEPPERMINT (*Mentha piperita*, L.).

Numerous requests for information regarding the cultivation of peppermint have been answered by the division during the past year. About four-fifths of the world's supply of peppermint oil is produced in this country, the annual product amounting to nearly $1,000,000.

In addition to information given on this subject in former reports the following from Mr. P. F. Hagenbuch, a successful peppermint-grower of Saint Joseph County, Mich., has been furnished by request:

To grow mint successfully requires a good, heavy, sandy loam and clean culture. Cleanliness is essential for two reasons: First, mint is a slow-growing plant, and if it is not kept clean it is soon overgrown; second, mint-oil, when pure, has a very fine flavor, while if any of the weeds known as mare-tail, fire-weed, smart-weed, or rag-weed are distilled with the mint it acquires an offensive odor, which prevents it selling readily.

Mint has been carried from this county into other States, but usually with poor success. It has proved a failure in California, Iowa, Illinois, and southern Minnesota, the plant having a large growth but little oil.

I understand that it grows with success on sandy loam in northern Minnesota; also that it has been taken to Mississippi and grown successfully there.

I believe peppermint is the most successful crop that can be grown upon the marsh mucks of Michigan. Last year my partner and myself grew $400 worth of oil upon 9 acres, and we have 25 acres now ready to plant. Our marsh is tiled every 6 rods, from 3 to 4 feet deep.

Mint must be planted in the spring as soon as it is possible to get upon the ground, as the roots start very early. We generally plant on clean clover sod, corn stubble, or old potato ground. It is the only crop that I know of that follows potatoes well. After the ground is plowed and harrowed it is marked out one way, from 2 feet 8 inches to 3 feet apart, with a shovel plow, care being taken to make but a short distance ahead of the planting, that the land may be fresh. In digging the roots for planting we first plow them out, then shake well with a fork and draw in piles to where they are to be planted, covering well with earth to keep them from becoming dry. In planting, a man takes a coffee-sack and fills it with roots well picked to pieces, then swings it across his shoulder; he now gets astride of the row, pulls the roots from the sack with his left hand, throws them into the furrow with his right, and kicks the earth over them from both sides with his feet. An old hand at the work can plant an acre a day, but a green hand can not make all fours go at once, and will not plant more than half an acre. Care should be taken to always keep good roots in the row and have no gaps. After planting comes the hoeing and cultivating, which must be done with great care. If the land is reasonably clean at first, this can be done at a cost of $4 or $5 dollars per acre for the season, but in foul grassy land I have known a man to hoe only a tenth of an acre a day.

About the last of July the plants begin to throw out runners and cultivation stops. The blossoms appear in the latter part of August, and the crop is then ready to distil. A distillery will cost $200 or more, according to the cost of boiler. A distillery consists of a boiler (15-horse capacity), two large tubs, 6 feet high and 5 feet 10 inches across the top, and a condenser made of tin pipes. The steam, admitted at the bottom of the tub, goes up through the mint and comes out at the top with the vapor of the oil; the vapors of both then pass into the condenser, upon which cold water is pumped, the condensed steam and oil running out below into a receiver, which resembles an old sprinkling can. The oil remains at the top in the can, and the water is drawn off below. We usually cut the mint far enough ahead to have it dry before distilling, as it then handles better and loses no oil in drying. Peppermint is more reliable to grow than spearmint, as the latter is more delicate, being very sensitive to drought, too much moisture, or frost; in fact, a hard frost will often diminish the yield of oil one-half.

Evening primrose (*Œnothera biennis*).

Mr. L. J. Germain, of Cuyahoga Falls, Ohio, has contributed a very full account of the medicinal properties of this plant, of which the following is an abstract:

In some of the Eastern States it is said to be used as a diaphoretic in fevers, and is there known as "fever plant." It is also said to be used there in the harvest field under the name of "coffee plant," for its invigorating qualities, and to slaken thirst and promote perspiration. In the Middle States it is generally known as "scabish plant," or wild Evening Primrose, and is in great repute for "summer complaints," such as ordinary diarrhea, cholera morbus, bloody flux, Asiatic cholera, cholera infantum, etc. The young roots are also grated fine, pulverized, or macerated with fresh lard, mutton tallow, or fresh butter, and applied as an unguent to cutaneous affections, such as burns, scalds, felons, bunions, erysipelas, cuts, and bruises. In the Southern States it is commonly known as "king's cure-all," and used by physicians to dispel gathering humors, such as boils or "gatherings." The negroes use it as an antitode for snake bites and as a poultice for wounds, causing them to heal by "first intention." For the latter purpose the usual method of preparing the poultice by country physicians is by boiling the leaves with wheat bran.

Another use for the plant is in cases of sun-stroke. Its reviving effect in such cases and the relief of the attending apoplexy is wonderful, as I have experienced in my own person and observed in others. It is also used as a soothing stimulant by the aged, infirm, and hypochondriacal. I have seen the tea used successfully to promote perspiration and check vomiting and spasms in a case of Asiatic cholera. I also used the same with good effect upon myself on one occasion in a case of ordinary cholera. On frequent occasions, during a series of years with a surveying party in the West, I have given it to my men for sudden attacks of bowel complaint, always with good results. In some cases better results seem to have been obtained

by a slight addition of alcohol to effect a more complete solution of some of the gummy principles. Sulphate of ether, instead of alcohol, has been used in desperate cases of cholera infantum and for the diarrhea which often follows scarlet fever.

I should also add that the blossoms placed in water form a mucilage excellent for inflamed eyes.

IMMEDIATE INFLUENCE OF CROSS-FERTILIZATION UPON THE FRUIT.

By A. A. Crozier, *Assistant Botanist.*

This subject has received renewed attention from horticulturists and others during the last few years, and has been an object of experiment by private growers and at several of the agricultural colleges and experiment stations. It is a question of considerable practical importance. If different varieties of plants growing together may affect directly the character of each other's fruits, the fact should be definitely known and the extent of such influence determined. From the evidence collected it appears that many growers believe that in at least some cases such an influence exists. Squashes and pumpkins, for example, are believed to affect melons growing in their vicinity. In certain sections it has been the practice of market gardeners to plant an occasional hill of pumpkins in their fields of water-melons for the purpose of increasing the size and firmness of the melons for market. Among strawberry-growers it is widely believed that the berries of pistillate varieties will vary in character according to the staminate variety which furnishes the pollen. As many of the best varieties of strawberries are pistillate and require to be fertilized by some perfect flowered variety, it becomes important to know with certainty whether such an influence exists or not.

The question of the immediate influence of cross-fertilization upon the fruit has not heretofore received the attention of the Department. All the attainable evidence on the subject has therefore been collected both from growers and publications, and the principal portion of it, together with the results of a few additional experiments, is herewith printed. The total amount of existing testimony is considerable, but the amount of reliable evidence is small. The evidence here given, though sufficient, perhaps, to establish a probability, is intended mainly as a basis for a more complete study of the subject, which it is hoped will be made.

SUMMARY OF THE EVIDENCE.

Charles Darwin[8] gives a large amount of testimony to prove that cross-fertilization has an effect the first season upon the ovary or fruit as well as upon the seed; but he says that such an effect does not always follow, and that Mr. Knight, a careful observer, had never seen the fruit affected, though he had crossed thousands of apples and other fruits.

Dr. Asa Gray[10-12] contributes several articles on this subject to the American Journal of Science, and states that "it is generally agreed that the alteration of the character of the fruit is immediate, *i. e.*, that it affects the ovary itself," and adds: "Improbable as such an influence seems to be, it is hardly more so than the now authenticated fact that the graft of a variegated variety of a shrub or tree will slowly infect the stock."

Thomas Meehan, after publishing much on the subject in his Gardeners' Monthly,[19-22] reviews the whole question in an article in the

Rural New Yorker,[17] and concludes that there is not sufficient evidence to warrant a belief in the direct influence of pollen, except possibly in the case of Indian corn.

Mr. N. E. Hansen, a student at the Iowa Agricultural College, concludes from a large amount of testimony collected in 1887, and from some personal experiments, that foreign pollen does sometimes exert an immediate influence on the fruit.

The greatest amount of interest on the subject in this country has been in connection with the strawberry. Most growers who have given attention to the subject believe that there is a direct influence of foreign pollen, at least at times. At the last three sessions of the American Pomological Society the subject has been under discussion. Professor Lazenby, at the session of 1885,[2] reported experiments made in 1884 at the Ohio Experiment Station in which there was an apparently marked effect of foreign pollen upon the fruit of the strawberry. A repetition of the experiments in 1885, however, left the result in doubt.

In the same year[23] Mr. E. S. Goff, of the New York Experiment Station, crossed Crescent and Sharpless strawberries with other sorts and saw no influence of the cross. In 1886[24] he crossed the Crescent with pollen of three other varieties, but the fruit all appeared alike. In the same year he fertilized three varieties of black grapes with pollen of the white variety, Lady Washington, but observed no difference in the character of the resulting berries.

Thomas Wild, of Cooperville, Mich., has made numerous crosses in strawberries and believes that in some cases an influence of the cross is seen the first year. Perhaps the best evidences of immediate influence of foreign pollen is found in the case of corn. It will be borne in mind, however, that the ovary here is but a thin covering to the seed, and that any effect observed may be due solely to a change in the seed itself.

Mr. A. A. Crozier in 1879 crossed flint corn with Yellow Dent, and in 1886[5] crossed sweet corn and White Dent with Yellow Dent and observed an effect of the cross the same year.

Experiments at the U. S. Experiment Station by Dr. E. L. Sturtevant upon corn, though not undertaken for the purpose of determining this point, have satisfied him that there is an observable effect the first season.

Prof. S. M. Tracy states to the writer that he has crossed flint corn with yellow dent without observing any effect the first year. In other cases, however, an immediate effect has been seen.

Experiences like that recorded in the letter of D. M. Ferry & Co., given below, are so common that the general opinion that corn will "mix" the first year seems fairly well sustained.

Among *Cucurbitaceæ* it is generally believed that cross-fertilization readily occurs and that its effect appears in the fruit the first season. Pumpkins are supposed to influence the fruit of squashes growing in their vicinity; water-melons are thought to be especially liable to be injuried by citrons; and cucumbers have been said by good observers to affect the quality of muskmelons growing near.

In some experiments by M. Naudin,[10] a French scientist, on crossing in *Cucurbitaceæ*, the varieties in each species crossed readily and there seemed to be an effect the first season, but the species themselves refused to hybridize. Out of seventy trials between all the known species except one, in but five instances did the fruit set, and in none of these was there a perfect seed.

The letters of Mr. Baker and D. M. Ferry & Co., given below, together with the quotation from Mr. Darlington, are strong testimony in favor of an effect of a cross the first year. On the other hand, if such an effect exists, it is remarkable that such seedsmen as Messrs. Comstock, Kolb, and Henderson, as shown in their subjoined letters, have never observed it.

During the past season Professor Bailey,[4] Mr. Skeels,[25] and Mr. Crozier[6] each made successful crosses between different varieties of summer squashes, but the fruits differed in no observable respect from those self-fertilized.

In regard to the ordinary fruits the testimony is equally discordant. About 1873 Dr. B. D. Halsted and Mr. C. W. Garfield, under the direction of Dr. W. J. Beal, at the Michigan Agricultural College, made one hundred crosses between different varieties of apples. About twenty fruits were the result, some of which seemed to combine the characters of both parents. Both Dr. Halsted and Mr. Garfield believed at the time that these results were due to an influence of the pollen used. Dr. Halsted still holds to that opinion, but Mr. Garfield, in view of the variations which spontaneously appear among apples, now doubts whether the appearances then observed were due to the crossing.

Other experiments of the same nature have been made by students of Dr. Beal, but from none of them is he satisfied that there is an influence of a cross the first year.

In 1886 Dr. Halsted[16] crossed flowers of the Longfield apple with pollen of the Roman Stem. The resulting fruits combined the characters of both varieties and were believed to show a direct influence of the foreign pollen. Other crosses, made by himself and Prof. J. L. Budd at the Iowa Agricultural College, gave the same result.

In 1887 Prof. L. H. Bailey[4] crossed Hyslop crab with the Oldenburg apple, and another variety of crab with Sweet Romanite, but no change in the fruit was observed. He also crossed the Spiny-fruited *Datura stramonium* with pollen of the Smooth-fruited *Datura inermis* without observing any change in the character of the pods (see letter of Professor Bailey, given below). Among citrus fruits there is a prevalent belief in the immediate influence of cross-fertilization.

Mr. Hart, whose letter is given, and Mr. Lyman Phelps, of Sanford, Fla., believe that they have observed a change in the appearance of oranges due to the pollen of other varieties growing near. The Bahia, or Washington Navel orange is believed to be especially potent in impressing its peculiar mark upon other varieties; but as this variety produces very little pollen and is a shy bearer unless fertilized by other varieties, and as specimens having the Navel mark are found in varieties where no Navel trees exist, the evidence from this source for the immediate influence of pollen on the fruit does not seem to be conclusive. No direct experiments in the crossing of oranges to determine this point seem to have been made, though some are now in progress in the orange house of the Department of Agriculture. In the crosses between varieties of the orange which have been made by Mr. Saunders, superintendent of the Department grounds, and his assistants, no immediate influence has been observed.

A cross of a lemon with pollen of an orange was made the past season by Mr. Henry Pfister, head gardener at the Executive Mansion. The fruit is now (January, 1888) full size, and resembles the other lemons upon the same tree.

The following letters are given from among those received at the Department in response to inquiries upon this subject:

T. F. Baker, Bridgeton, N. J.:

In Maurice River and Fairfield Townships, Cumberland County, an occasional hill of pumpkins has been planted among water-melons. but not for the past three years. It increases the size very much, and also makes the rind harder, so that they endure handling and transportation better. The universal opinion of those who have practiced this method is that it had invariably a bad effect upon the quality, so that they have abandoned the practice.

There is ample evidence the first year of mixture, and seed from such stock is utterly worthless where good toothsome melons are desired.

Prof. L. H. Bailey, jr., Agricultural College, Mich.:

I have performed many crosses this year between such plants as would give unmistakable evidence of the immediate effect of pollen should such effect occur. I crossed Hyslop crab with Duchess of Oldenburg and got no effect in any way, not even in season of maturity or texture. I crossed another crab with Sweet Romanite and obtained no immediate effect.

By the way, I made a singular incidental experiment on these varieties. Of five crabs I removed four of the pistils and crossed the remaining one. From these crosses I got two mature apples, but they had seeds in only one cell.

I crossed many Crookneck squashes with the White Scallop or Summer Turban. The squashes are nearly mature, but there is no immediate effect whatever. In order to test the matter more fully I hybridized two plants which have exceedingly dissimilar fruits. These are *Datura stramonium* (Jamestown weed) and *D. inermis.* The former has very prickly pods, the latter very smooth ones. I have made reciprocal hybridizations, but there is no immediate effect of pollen. I have never yet seen any immediate effect of pollen. I am very careful in making my crosses, and I know that I have made no mistake. I do all the work myself I use manilla bags on both pistillate and staminate flowers, and I leave them on the pistillate flowers a week after the operation is performed.

Prof. J. L. Budd, Agricultural College, Ames, Iowa:

The most marked variation in the shape of fruit was in the crossing of the Roman Stem on the *Pyrus coronaria.* Some of the specimens were so like Roman Stem in shape and in the peculiar stem and basin as to be difficult to separate, except by color of skin and texture and flavor of flesh.

But we have had a number of essential changes where we have crossed remotely connected varieties and species. Roman Stem on the Russian Silken Leaf apple has given some peculiar changes of fruit.

Next year I will report more carefully. I have never doubted the possibility of a change of fruits in this way since I crossed the Colfax strawberry twenty-five years ago.

William G. Comstock, East Hartford, Conn.:

In all my experience, and I have been a practical seed-grower fifty years, I have never seen any mixture in the fruit the first year from cross-fertilization, but from seeds of the crossed specimens planted the next year fruits have been produced in which the mixture has been plainly shown. I never knew a melon to partake of the cucumber flavor or to show any spines. The smooth-stemmed squashes, like the Boston Marrow and Hubbard, do not mix with the rough angular-stemmed varieties like the Crookneck, nor with the field pumpkin.

William Darlington, in his work on American Weeds and Useful Plants, p. 142, says:

When growing in the immediate vicinity of squashes the fruit of this species (*Cucurbita pepo*, Pumpkin) is liable to be converted into a hybrid of little or no value. I have had a crop of pumpkins totally spoiled by inadvertently planting squashes among them, the fruit becoming very hard and warty, unfit for the table and unsafe to give to cattle.

F. S. Earle, Cobden, Ill., writes:

The question of the immediate influence of cross-fertilization is an important one, and I am glad you are investigating it. I think there is no question that the fruit of pistillate varieties of strawberries varies when fertilized by different staminate varieties, but I have always suspected that the more abundant pollen, and conse-

quent more perfect pollination afforded by some varieties, had quite as much to do with the difference in the result as any true effect of the cross-fertilization. Reliable experiments are badly needed on this subject, but I am sorry to say I have none to report. Practical fruit-growers are always too much rushed by work that can not be put off to conduct experiments with the care necessary to give them scientific value.

D. M. Ferry & Co., Detroit, Mich.:

Concerning the effect of cross-fertilization, we would say that whatever observations we have made have not been recorded and the attending circumstances carefully enough noted to make them of any value from a scientific point of view, but they have been extensive enough to convince us that very often, but not uniformly even in the same species and variety, the pollen does affect the developing fruit.

There is not a season but what we have experiences like this: A certain stock of sweet corn is divided between two or more growers. All but one of the fields grown from that are perfectly clear of any trace of field corn; but one corners on a field of field corn, and in that field, and very markedly on the side nearest the field corn, we find much mixture of yellow and crossed grains. If this was a result of previous impregnation why should it show itself in this field and in no other?

Similar results have been noticed in cucumbers, squashes, and water-melons; that is, a field near some other variety will have a greater or less number of melons which are clearly crossed, or "off type," but other fields planted from the same bag and not near other fields would seem perfectly pure.

Again, in 1883 and 1884 we made a large number of crosses between different varieties of peas, carefully emasculating the blossoms used, and had quite a number of pods of smooth and yellow-fruited varieties which had been fertilized by wrinkled sorts which would have the same pod peas of the normal type and color and others which were distinctly and very clearly wrinkled and of a green color.

Again, in the pickings from our crop of peas and beans which have been reported as grown too near other sorts we see a marked trace of the neighboring sort. We know it is claimed by some that peas and beans are self-fertilizing, but we have learned that they are not always so, to our cost. We are sorry we can not give you more explicit data, but have done what we could.

E. H. Hart, Federal Point, Fla.:

Among oranges the influence of cross-fertilization is constantly apparent. I have a number of trees of an imported variety of the orange called "Long," the fruit of which has always been extremely elongated. The row next to these was budded several years ago with a flat orange which bloomed and set fruit for the first time this season. The pollen of these flat oranges has modified the long oranges next to them to such a degree that the latter are nearly all round, and some of them flattened, a feature never before observed.

The Navel orange is one of the most potent to leave its marks on other kinds in its vicinity.

Peter Henderson, New York City, N. Y.:

We have cultivated on an acre of ground during the last twenty years an average of thirty varieties of strawberries, running side by side. Among these varieties some were pistillate, some staminate, and some having perfect flowers, and yet with the most careful observation I have never observed the slightest variation in the fruit from such a mixture of varieties. You say that it is generally believed in *Cucurbitaceæ* that a cross affects the fruit the first year, I have incontrovertible evidence that it does not. In our trial grounds, where probably fifty different species and varieties of *Cucurbitaceæ* are planted, so that we can examine the types, the closest observation has failed to show us a single instance where the fruit has been changed in the slightest degree. That the seeds of kinds so planted become mixed we well know, but the fruit proper is certainly never changed.

R. F. Kolb, Auburn, Ala.:

I have been growing melons for fifteen years, and am one of the largest growers in the South, my average crop being over 200 acres. There is never any evidence of mixing in the appearance of the fruit the first season, provided the seeds planted are perfectly pure and true to variety. You might plant two or more varieties of melons near each other, and if the seeds of each are perfectly pure when planted you would observe no mixing the first year in the appearance of the fruit, but if the seeds of either variety so planted were again planted the next season you would find among the crop various hybrids. In other words, the mixing goes into the seed the first year, but does not show itself in the appearance of the fruit.

Prof. James Troop, Purdue University, La Fayette, Ind.:

In regard to the immediate effect of cross-fertilization upon the fruit, I have tried the experiment here only on strawberries. Two years ago I tried it on several varieties, among them Crescent fertilized by Sharpless. I thought then that the sharp acid flavor of the Crescent was considerably toned down. This year my students tried the same thing, using Crescent for the female and Sharpless pollen, but we could not discover any change whatever in the flavor, size, or color.

While at Lansing, about 1881, I crossed Northern Spy and Golden Russet apples, crossing both ways, but the Spys were Spys, and the Russets remained the same as those on the rest of the tree.

I would hesitate to give an opinion either way until I have made further tests.

Hiram Sibley & Co., Chicago, Ill. (F. A. Warner):

As far as we have learned from information from our best growers here cross-fertilization does not appear during the first year.

The writer has known it in the case of corn not to appear in any marked degree until the second year, and with a certain knowledge that the cross was made during the year previous, as the planting of the seed the second year was too distant to have cross-fertilization occur.

CONCLUSION.

Considering all the testimony given above the writer is disposed to think that the evidence is still insufficient to show that there is an observable effect of a cross upon the ovary or fruit the first year, except in Indian corn, in which case his own observation will not permit him to doubt. It seems most reasonable to suppose that ordinary cases of apparent cross, observed where different varieties are grown together, are due to admixture of a previous year. It is admitted, however, that there are observations which can not be explained in this way. The occasional variations in the appearance of apples and other fruits, which have been supposed to indicate an immediate influence of pollen, have not been proved to be due to that cause. The argument from seedless fruits, which is sometimes made, seems inconclusive, for it has not been shown that fertilization is necessary to their production, though in numbers of other cases it has been proved that without fertilization no fruit matures. Even if true that the ovary, or even a larger portion of the plant, may be caused to develop by pollen without the intervention of the ovules, it requires better evidence than is yet offered to show that an immediate change in its character will result from the use of pollen of a different variety.

SUGGESTIONS FOR FUTURE EXPERIMENTS.

For those who may wish to experiment further on this subject the following suggestions are appended:

(1) Select varieties which you have reason to believe will readily cross.

(2) Select such as by their difference in form or color will readily show the effect of a cross if there be one.

(3) Use every precaution to prevent self-fertilization. To this end the selection, where practicable, of plants having separate sexes is desirable.

(4) For the same reason cover the crossed flowers for some time before and after fertilization with muslin or paper sacks, and exercise great care in applying the pollen.

(5) Mark plainly and securely the flowers experimented upon that there may be no mistake in the identity of the specimens when mature.

(6) Duplicate the experiments. The chances of failnre are numerous, and there is continual danger of the loss of specimens up to the time of maturity. Errors of observation, and the liability of any observed change being due to other causes, are also greatly lessened by the multiplicity of specimens.

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23, 24. New York Experiment Station Report, "Influence of Different Pollens upon the Character of the Strawberry," 1885, p. 255: "Influence of Foreign Pollen upon the Character of Fruit," 1886, p. 179.

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SECONDARY RESULTS OF POLLINATION.

By E. W. CLAYPOLE, *Akron, Ohio.*

[The following paper was read before the Botanical Club of the American Association for the Advancement of Science at the New York meeting, August, 1881. It has not heretofore been published, and has been secured for this report mainly for its bearing on the topic of the preceding paper.]

The functions of the pollen and of the ovule, respectively, in the production of seed are so well established by observation that there is no occasion to say anything in explanation. The growth of the pollen tube and its elongation and penetration of the conductive tissue of the style may be seen in certain flowers by any tyro of the microscope. The passage of the fovilla, or fertilizing material, down the pollen tube to the micropyle, its entrance, and its union with the protoplastic material of the ovule, are fundamental truths in vegetable physiology, though our faith in most cases rests rather on testi-

mony than on observation. The subsequent changes that result from the union, the sudden stimulus given to cell multiplication, the rapid enlargement of the ovary, and the development and ripening of the ovules into seeds, are easily seen and are familiar to every one. However mysterious, this is the ordinary process of nature, and is in accord with the elementary principles of botany.

But in some cases things do not happen in this ordinary way, or just as our text-books say they should happen, and then there comes in a little difficulty in explaining how the results are accomplished.

Seeing, as we constantly do, the close connection between the fertilization of the ovule and the growth and maturation of the fruit, we are naturally led to the almost unconscious belief that one of these events is the consequence of the other, that the growth of the fruit is a consequence of the growth of the seed. And when we observe the countless cases in which the failure of the ovule is followed by the fall of the young fruit the unconscious belief becomes almost irresistible. A shower of rain washes away the pollen and our apple crop fails in consequence. The young fruit does not swell, but shrinks and falls. This happens so often and in so many plants that we cease to expect fruit where there is no seed.

Yet there are some facts that at least tend to show that the connection between the seed and the fruit is less close than we sometimes assume. Some of these also lead us to believe that the fertilizing influence of the pollen is not confined to the ovule.

As the first example of these secondary results, I will mention the obvious, but seldom noted, fact that the ovary can be developed and matured without the presence of the seed. This apparently proves that the swelling of the ovary is independent of the development and ripening of the ovule. It may be due to the direct action of the pollen on the ovarian tissue, but even this does not seem in all cases to be necessary.

As an illustration of this statement I will quote the Banana, which, as is well known, never bears any seeds at all. The fruit is solely the swollen and matured ovary, in which numerous abortive ovules may usually be seen.

The St. Michael's orange is another case in point. Though small, this variety is accounted the best of the many kinds cultivated in Europe, as it seldom contains a single pip. It has apparently been introduced into this country, as I have recently seen some oranges that were said to have come from Florida which, by the absence of seeds, formed a pleasant contrast to the usual seediness of the Florida fruit. (This variety is now grown in Florida and California.)

Again, our common Persimmon is sometimes entirely seedless. Once in Pennsylvania I met with a whole grove of these trees in which a seed-bearing fruit was the exception. The garden Radish also will often develop its pods without any seed. Any one, too, who will take the trouble to examine the fruits of the common Maple will soon learn that a large proportion of them contain no seed, but are simply hollow shells.

The well-known Sultana raisins sold in our stores owe the esteem in which they are held to the total absence of seeds, and the high-bred European Malaga grape is found almost as often without seeds as with them.

Less noticeable, but equally true and apposite, are the numerous instances, familiar to every careful observer, of cherries, plums, and peaches whose stones contain no kernels. All these facts abundantly

prove that the development of the embryo into a seed is not absolutely necessary, at least in these plants, for the full growth of the ovary into a fruit.

We may go yet further. The above-noted cases may be explained by the action of the pollen, not on the ovule, but on the tissue of the ovary itself. It may be said that the stimulation of cell growth, which is usually supposed to start with the ovule, was in all cases felt directly by the ovary. Be this as it may, we are compelled by these facts to admit that the effects of pollination are not limited to the ovule, but extend also to the ovary, even when the ovule is absent or abortive.

But the case of the apple and the pear shows a difference. Here, though the pips usually develop, the effect of the pollen extends beyond them. As before, it affects the ovary, but does not stop there. The calyx is involved, and, according to the views of some, the flower-stalks also. The effects of the pollen are therefore in this fruit felt by the ovule, the ovary, the calyx, and possibly by the flower-stalk.

What is true of the apple is also true of the pear, the quince, the medlar, the hawthorne, and many other plants of the Rose family. Their fruit is constructed on the same pattern, and the action of the pollen in all such cases must therefore be equally extensive.

But we may go even beyond this. We have all seen apples that contained no pips and yet were fully grown and showed all the characters of the variety. In these cases, as in those of the seedless orange, the banana, etc., the fertilizing effect of the pollen must have been directly exerted on the ovary without the intervention of the ovule.

A similar case is presented by a mulberry tree belonging to a friend of the writer. It is of the pistillate kind and is annually laden with fine fruit, though no staminate tree grows in the neighborhood and no staminate flowers can be found on the tree itself. Examination of the fruit also shows that the seeming seeds are merely shells without embryos. To assume that no pollen was concerned in the production of this fruit would be going too far, but it does seem the influence of the pollen, if present, must have been exerted directly on the ovary without the assistance of the ovule.

Further still, we now and then find an apple or a pear which contains no pip, but also no core, so that the very ovary itself is lacking. Yet such apples often grow to the usual size and if not always well flavored are nevertheless true fruits. This is usually the case when the tree has flowered out of season. A horticultural friend of mine has informed me that in the year 1832, when he was a boy, a late frost killed the apples, and that in the fall out of a peck or so of wretched fruit, which was all that the orchard produced, not a single one had a pip or a core.

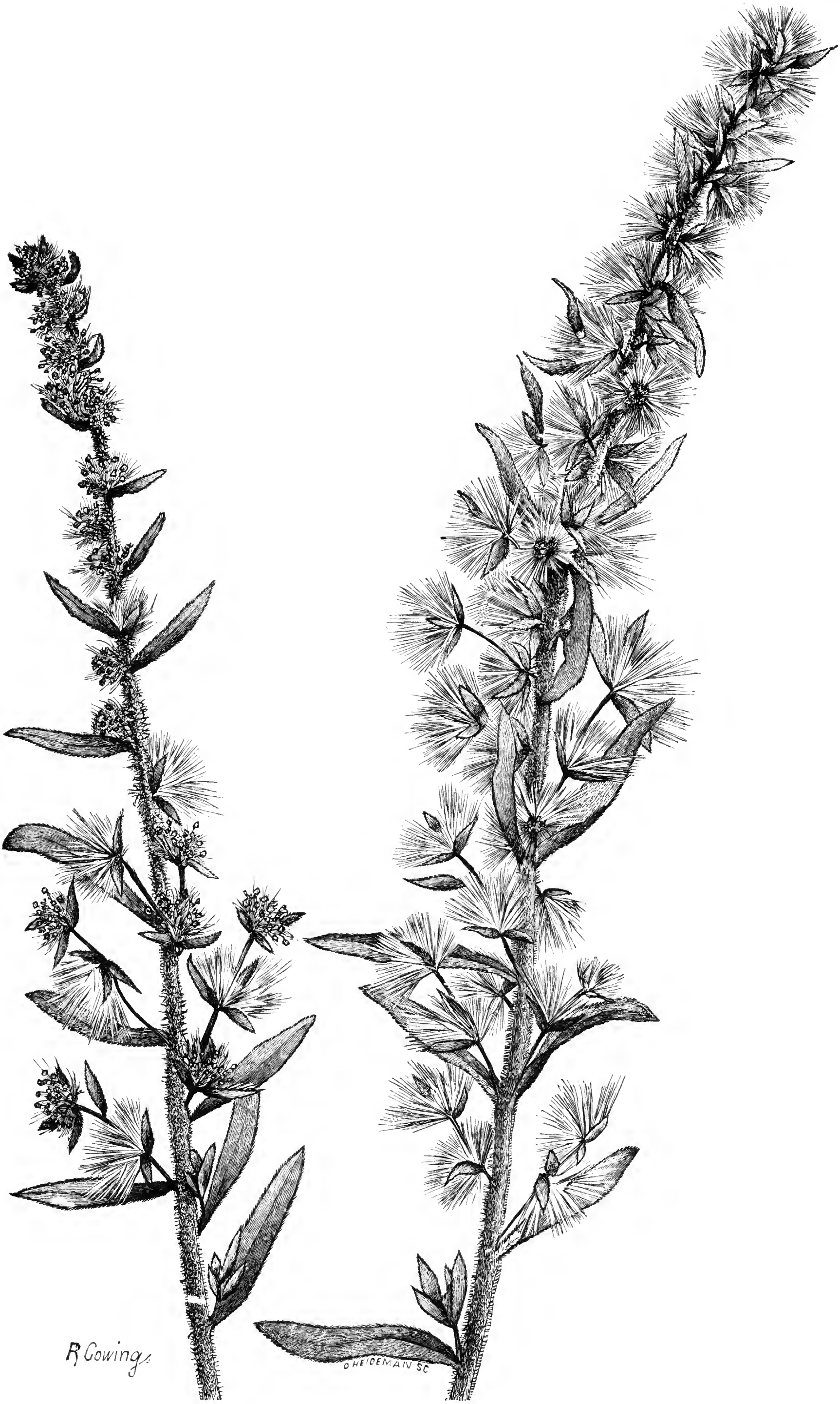
The following extract from a letter published in Nature on November 4, 1886, bears on the same point. In it Dr. Maxwell Masters, the editor of the Gardener's Chronicle, says:

> The second crop of blossoms in pear trees is usually produced on shoots of the same year and they are often imperfect. The Napoleon produces some every year. Every year, too, I receive from the Trinity Botanical Garden, at Dublin, Bishop's Thumb pears on the summer shoots. They are more like fingers than "thumbs" and have no core. The fruit is eatable, but the carpels are absent.

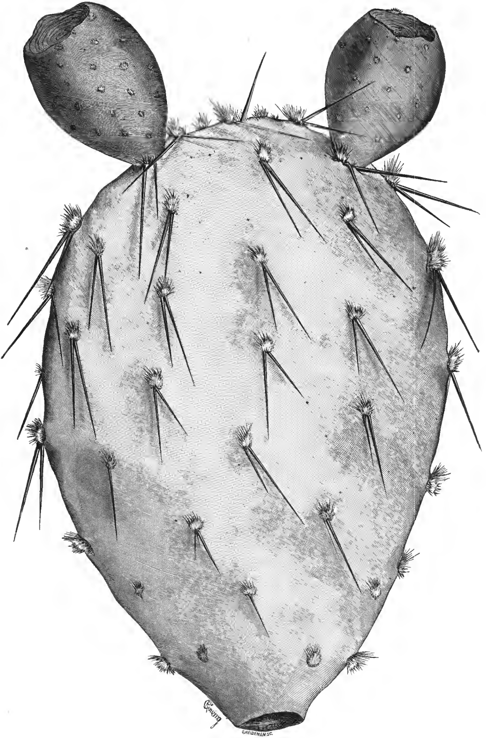
We have here, apparently, a case of the direct action of the pollen on the calyx of the flower, perhaps through the medium of a rudimentary stigma and ovary, which were afterwards atrophied.

EUCHLÆNA LUXURIANS (TEOSINTE).

1. Male flowers. 2. Female flowers inclosed in sheath. 3. Seeds.

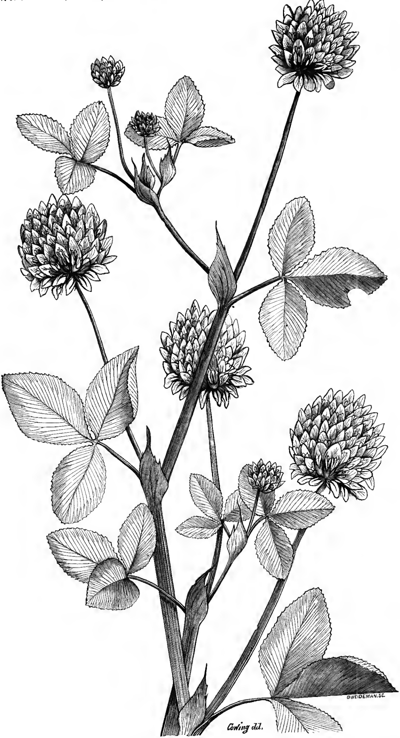


EUROTIA LANATA (WHITE SAGE).

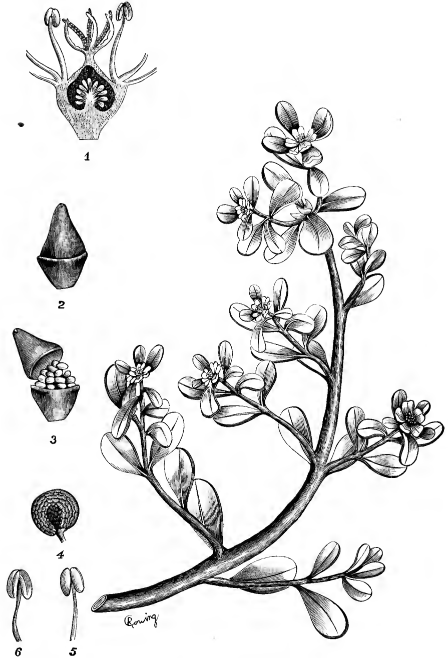


OPUNT ENGELMANNI.

ONOBRYCHIS SATIVA (SAINFOIN, ESPARSET).
1, 2, 3, 4. Parts of the flower. 5. The pod. 6, 7. The seed.

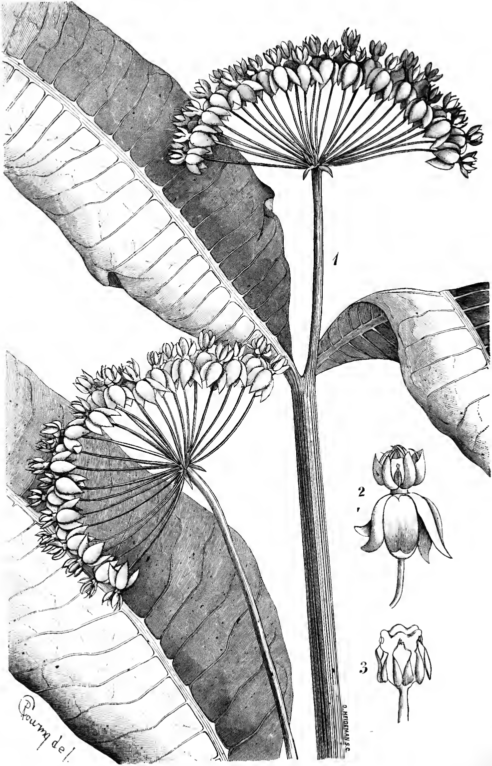


TRIFOLIUM HYBRIDUM (ALSIKE CLOVER).



PORTULACA OLERACEA (PURSLANE).

1. Longitudinal section of flower. 2 to 6. Ovary, seed, etc., magnified.

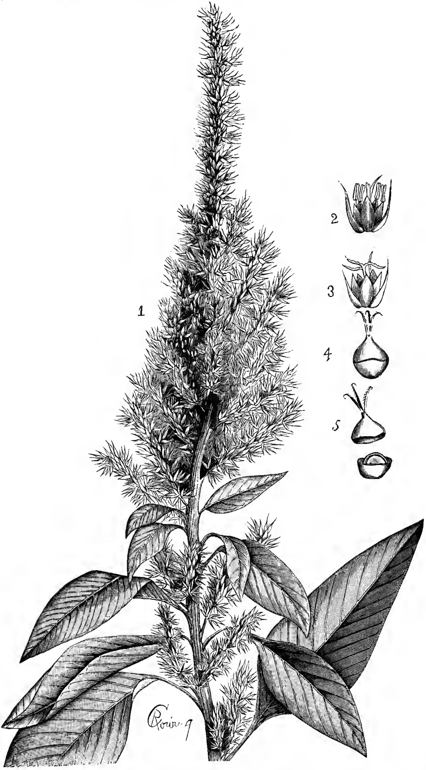


ASCLEPIAS CORNUTI (MILKWEED).

RANUNCULUS SCELERATUS (CURSED CROWFOOT).

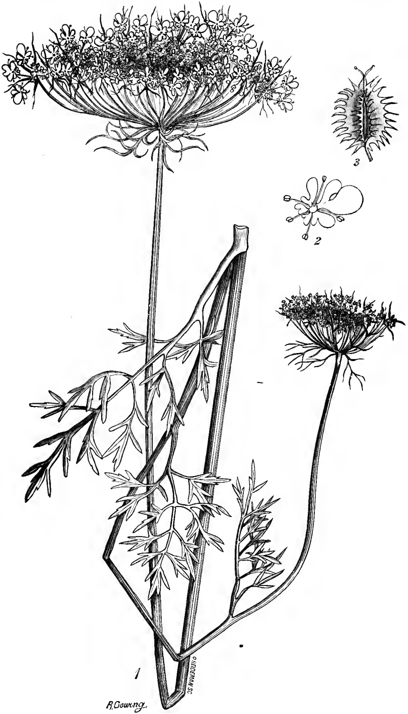
CHONDRILLA JUNCEA.
Root-leaves and top of the stem.

HYPERICUM PERFORATUM (ST. JOHN'S WORT).



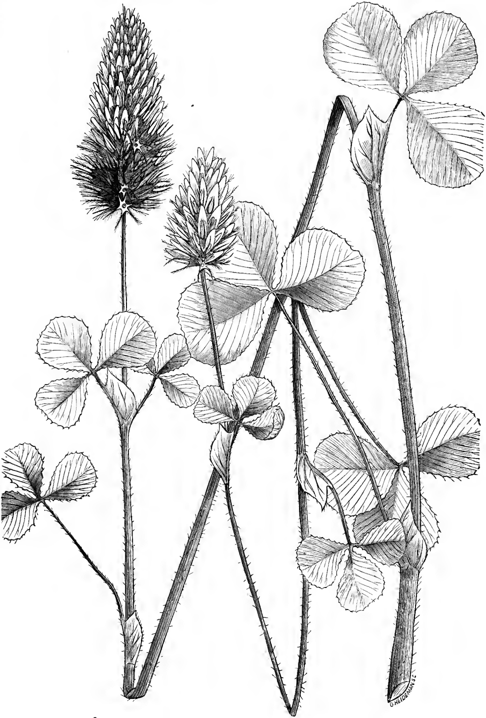
AMARANTUS HYBRIDUS (PIG-WEED).

2. Male flower. 3. Female flower. 4, 5. Ovary and seed, magnified.



DAUCUS CAROT. (WILD CARROT).

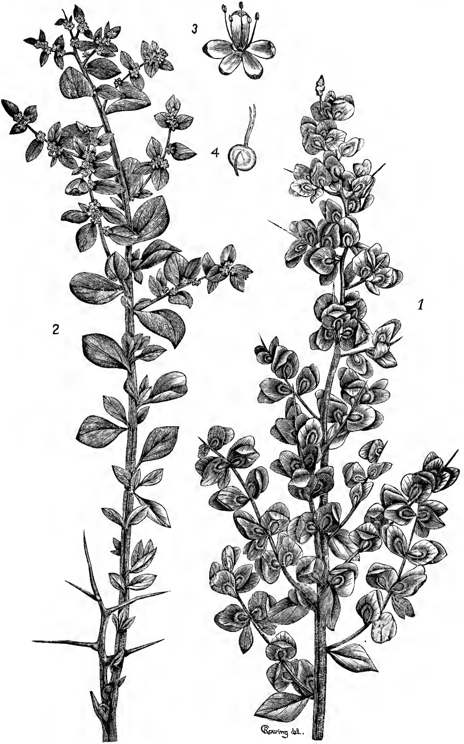
CYPERUS ROTUNDUS (NUT-GRASS, COCO).
2 A string of tubers. 3. A flower, magnified



Cowing del.

TRIFOLIUM INCARNATUM.

BERBERIS VULGARIS (BARBERRY).



ATRIPLEX CONFERTIFOLIA (WHITE SAGE).
1. Female plant. 2. Male plant. 3. Male flower. 4. Ovary and styles.

ARTEMISIA FRIGIDA (SILVERY WORMWOOD)

In not a few fruits, so-called, the action of the pollen goes, seemingly, farther still. In the Strawberry is involved the receptacle, and the same is true to a less degree of the Blackberry and the Raspberry. The calyx grows with the growth of the seed in the Hazelnut, the Chestnut, the Hickories, and the Walnuts ; also, in the little Partridge-berry, the Blue-berry, and the Huckleberry. The head of the flowering stem swells and sweetens and becomes the chief part of the Fig, and the bracts that inclose the flower and seeds compose the so-called fruit of the Pine-apple.

Where, then, shall we limit the action of the fertilizing element of the pollen? I am inclined to believe that it really has no limit, but that it is capable of extending through the whole plant.

Two facts in support of this opinion must here suffice. Most gardeners know that Pansies can not be well kept true to color when grown together in a bed for years in succession. Not only the seedlings, as might be expected, but the parent roots are apparently influenced by receiving each other's pollen and their colors thereby changed. The same is true of some other garden flowers. A friend of mine, who is largely engaged in growing the Gladiolus, has told me that for years he grew the "Shakespeare," a white variety, by itself, and year after year it remained true to color. But when for some reason he planted it one year near red varieties, the next year the same bulbs threw up stems that produced flowers that were partially red. Nor while they grew together could he again obtain perfectly white flowers.

These and other examples that might have been mentioned strongly indicate change in the parent plant, more extensive than those involved in the mere production of seed, or even of seed and fruit. They suggest a constitutional modification of varying and sometimes of wide range, involving other organs than those directly concerned in fructification, and enduring for years after the immediate cause has ceased to act. It seems far from improbable that a single act of fertilization may, in some cases, so change the nature of the parent plant that it may not again, throughout its whole life, be what it had previously been. Some of the occult variations that occur among plants may have their cause in the potent influence of pollen on the constitution of the parent.

The other kingdom of animated nature supplies facts that lend strong support to the view above stated. Without going into detail, it will suffice to say that the influence of the male animal is often permanent, and that young, subsequently produced, will show traces of it.

The influence of a quagga on a mare has been known to reveal itself years afterward by the production of a colt showing in several places the stripes of his stepfather. Darwin has collected several such cases, and many more might, without doubt, be brought together by a little investigation among men engaged in the breeding of animals. The subject, however, especially with regard to plants, has not received the attention which its importance deserves.

REPORT OF THE SECTION OF VEGETABLE PATHOLOGY.

SIR: I have the honor to present herewith my first annual report as chief of the Section of Vegetable Pathology, being the second report of the section of the Botanical Division devoted to the investigation of the fungus diseases of plants.

The constantly increasing correspondence has occupied much time and has been an important means of diffusing knowledge relative to plant diseases and the relations of our fungus pests to agriculture.

The collections of material illustrating the families of fungi have been considerably increased during the year and the specimens have been properly arranged for ready reference. There are now in the collection 5,572 sheets, standard herbarium size, on which are mounted 9,300 labeled specimens, in 3,000 pockets of uniform size, $6\frac{1}{2}$ by $3\frac{3}{4}$ inches; there are an equal number of specimens, largely duplicates of those mounted, arranged in order by host, constituting what we term the economic collection.

Permanent mounts of microscopical preparations, to the number of about 500, have been made of material under investigation during the year. The series of slides illustrating the downy mildew, the grape-rot producing fungi, and the smuts and rusts of grains and grasses are particularly full. Thanks are due to Mr. W. W. Calkins for a large and well-prepared collection of Florida fungi, and to Prof. S. M. Tracy for a particularly interesting collection of Western species. A collection of European fungi of the vine has been presented by Prof. P. Viala. This is particularly valuable as illustrating the species described in Professor Viala's work, "Les Maladies de la Vigne."

Many valuable specimens have been acquired through correspondents who have submitted them for examination, affording valuable material for future investigations.

I.—NOTES ON THE DISEASES OF THE VINE.

The study of the fungus diseases of the vine has been continued, particular attention being given to the subject of the treatment of mildew and black-rot. A detailed account of the work of the Section in this direction has been published in a special bulletin.

Throughout the Atlantic and Southern States the season of growth was generally wet and the weather such as to promote the development of fungi. From western New York through Ohio, Indiana, Michigan, Wisconsin, Illinois, and Missouri a long-continued drought prevailed, preventing the development of destructive plant parasites, and from this section there have been very few complaints of the ravages of fungi.

The downy mildew, black-rot, and anthracnose were especially prevalent, the two first named causing serious injury to the vines or great losses in the crops in New Jersey, Maryland, Virginia, North Carolina, and in the States south and west from the latter point. In California the ravages occasioned by oïdium and downy mildew have been slight, and it has been discovered that the latter disease is at present limited to a few restricted areas in that State. There is no evidence that the black-rot, so destructive in Eastern vineyards, has yet appeared on the Pacific slope.

Pourridie or grape root-rot has been discovered at several points—Missouri, Texas, and California—and its range will doubtless be extended by further observation.

As a result of field investigations two new forms of grape-rot have been discovered—bitter-rot and white-rot. The former is the most widely distributed, having been observed in the States in the East and as far west as Texas. The latter has been seen only in the extreme southwestern part of Missouri and adjacent parts of Indian Territory.

*A.—Bitter-rot of grapes.**

Although this disease appears to have been known to our viticulturists for several years, its cause was only recently determined. In company with Professor Viala, of the National School of Agriculture of Montpellier, France, I observed the disease for the first time in the vineyard of Hon. Wharton J. Green, at Fayetteville, N. C. From the studies there made, and from subsequent laboratory investigations, the characters of the parasite causing the malady were determined and were made the subject of a communication to the French Academy of Sciences.

It appears that the fungus is both saprophytic and parasitic in its habits and occasions very considerable destruction of the fruit, especially of certain white varieties, the Martha for example.

That which especially characterizes this disease in distinction from the black-rot is that it begins its ravages at the time when the berries commence to ripen, and continues until their perfect maturity. Excessive humidity is even more essential to its development than to that of the Physalospora. The importance of this malady is evident, for, under favoring conditions, it may destroy the fruit that has escaped the ravages of black-rot. The fungus attacks the shoots, the common peduncle of the bunches and its ramifications, but it is upon the berries that its action is most conspicuous. A rosy discoloration, brighter on varieties with white fruits than on dark colored sorts, is the first manifestation of the disease. This discoloration extends rapidly by concentric zones until the whole berry is involved, the berries, however, retaining their original contour, or only appearing to be slightly wilted, and becoming even more juicy than is normal. Soon numerous small, slightly elevated points appear over the surface, and in two or three days these little elevations, which are the points where the fungus is maturing its fruit, have completed their development. The berry then becomes shriveled, as in the case of black-rot, but in a different fashion. The berry remains clear brown or deep purple in color, never becoming so black as in black-rot, and

* Accounts of this disease have been published in Comptes Rendus, Sept, 12, 1887; Agricultural Science, vol. I, p. 210; Colman's Rural World, Oct. 13, 1887; Proceedings New Jersey Horticultural Society for 1887, p. 114.

the pustules which stud the surface are less numerous and less convex. In advanced stages the berries lose their hold upon the pedicels and fall to the ground at the slightest jar. Those destroyed by black-rot usually remain strongly adherent and generally fall with their pedicels attached.

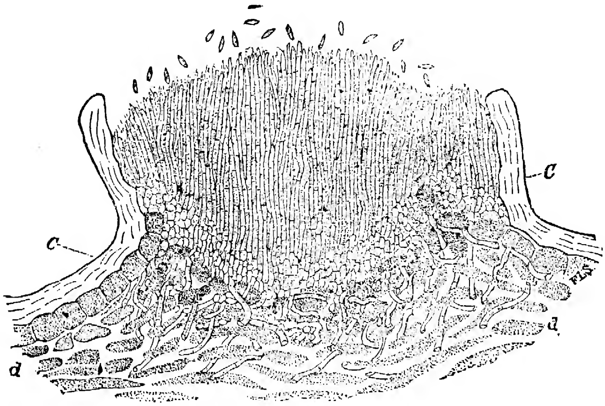


FIG. 1. Illustrates a highly magnified vertical section through one of the fruiting pustules of the fungus of Bitter-rot. A compact growth of spore-bearing hyphæ has burst through the epidermis, *c*, *c*. Below is the browned and dead tissue of the berry, *d*, *d*, growing through which are the mycelial threads of the fungus.

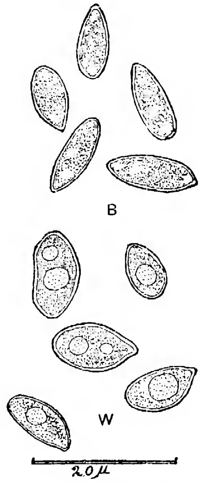


FIG. 2. Spores of Bitter-rot, B, and White-rot, W.

The mycelium of the fungus of bitter-rot penetrates the tissues of the berries, even entering the seeds, for upon the latter it is not uncommon to find the fruit of the parasite.

The spores produced are very minute, ovoid or navicular-form, and have rather thick walls. They germinate quickly when sown in aerated juice of grapes diluted with water.

Bitter-rot is most to be feared when frequent rains occur during the ripening period, but, like other fungus diseases of this class, it is sure to be most severe in poorly drained soils and on vines previously weakened by mildew.

B.—White-rot.

This disease appears to be of American origin, although the fungus causing it was first recognized in Italy, in 1878. In 1886 it was discovered in France, and during the past season (1887) has become widely spread, in the latter country, occasioning no little alarm. Frequent accounts of it have been published in French and Italian journals, the most complete and best illustrated being that given by Dr. F. Cavara.*

Since its discovery in this country, in September of the present year, it has been described by the writer in Colman's Rural World, October 27, 1887; and in the proceedings of the New Jersey Horticultural Society for 1887, p. 139.

* Intorno al Disseccamento dei Grappoli della Vite. Instituto Botanico della R. Universita di Pavia, 1888, p. 11, Pl. IV[a].

The mycelium of the fungus (*Coniothyrium diplodiella*) is found to be abundant in the pulp of the berries attacked, and it sometimes fruits upon the surface of the seeds. Generally, the fungus first attacks the common peduncle or branches of the cluster and, by interrupting the circulation of the nourishing fluids, causes the berries to wither and dry up. In such cases the berries may or may not be directly attacked. Infection of the peduncle or pedicels with germinating spores is easily effected, but attempts to infect the berries have so far failed.

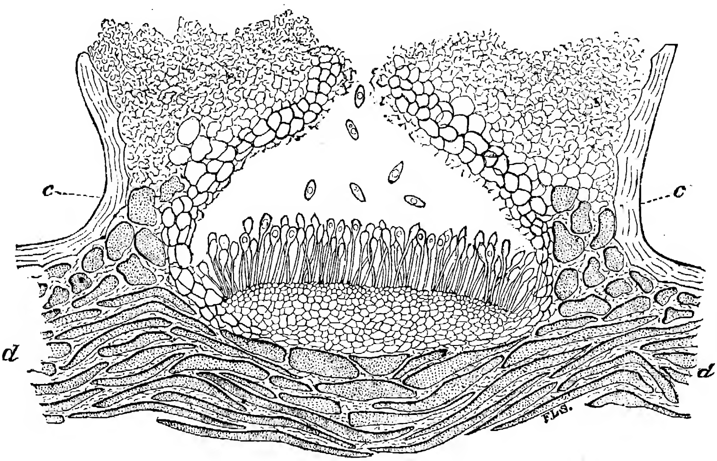


FIG. 3. A vertical section through one of the fruiting pustules—pycnidia—of the fungus of White-rot. *c c*, cuticle of the berry that has been broken through by the development of the fungus. *d d*, browned and dry tissue of the berry. The simple spores are borne on slender stalks arising from a layer of very delicate tissue at the bottom of the pycnidium.

Like the black-rot fungus, this produces minute pycnidia or spore conceptacles, which appear at the moment when the berries commence to ripen. These lie just beneath the cuticle, through which they finally burst, first appearing as shining, rosy points, then white, and finally brown. When fully developed, the pycnidia are surrounded by a thin membrane of a rather dark brown color. The ovoid spores are borne upon slender stalks or basidia, either simple or branched, which spring from a layer of very delicate tissue occupying the lower part of the pycnidium. They are at first colorless, but eventually assume a brown tint. At a temperature of 65° they germinate readily in water, pushing out germ-tubes from any part of their surface.

No remedy is known for white-rot, but it has been observed here, and very generally in France, that where the vineyards have been treated with eau celeste or the Bordeaux mixture the disease was far less prevalent than in similarly located vineyards not treated.

C.—Grape-leaf spot disease and black-rot.

In Bulletin 2 of the Botanical Division, page 40, Grape-leaf spot disease was treated as distinct from black-rot, for the writer at that

time was not convinced of their identity, although the close similarity of the pycnidial spores of *Phyllosticta labruscæ* with those of *Phoma uvicola* was, of course, observed.

Special attention has been directed to this subject during the past summer, and, as the result of extended field observations, I have been forced to conclude that the grape-leaf spot fungus and the fungus of black-rot of grapes is one and the same. In France the *Phyllosticta labruscæ* has been observed only in those vineyards affected with black-rot, and the same holds true for the United States. Wherever the *Phyllosticta* occurs it is in regions where black-rot prevails. In California, where the latter disease has not yet appeared, no signs of the fungus upon the leaves of the vines was discovered.

The brown spots upon the leaves figured and described in my report on the Fungus Diseases of the Vine* must, then, be regarded as simply the manifestation of the black-rot on the foliage.

The fact of the identity of the leaf form with that occurring upon the berries is especially important in connection with the question of treatment, for black-rot, like the downy mildew, must be treated preventively. As a rule, the black-rot fungus first attacks the leaves some days and often a week or two before the berries are affected. It may sometimes be observed on the foliage even before the vines have bloomed.

By watching the foliage the vineyardist may be warned of the presence of this dreaded parasite in good season, and upon the first signs of its manifestations upon the leaves he ought to begin the application of remedies or preventives in order to protect the fruit. Evidence is accumulating that the sulphate of copper compounds possess some value in checking this disease. We have been assured by some experimenters that there was a very decided improvement in respect to black-rot in vineyards treated with these preparations compared with those not treated. In France, also, similar results have been reported. M. Prillieux, in a communication addressed to the French minister of agriculture, says:

> It seems that treatments with the salts of copper will very economically replace the difficult and costly method of collecting and destroying the leaves affected by black-rot. M. Frechou has been assured by his laboratory experiments, carried on at Nerac, the results of which will finally be made public, that the slightest trace of sulphate of copper is sufficient to render impossible the germination of the spores of *Phoma uvicola* as well as those of *Peronospora*, and on the other side, the slight injury caused by black-rot in the valley of Herault upon vines treated by eau celeste or Bordeaux mixture for the downy mildew ought to afford some hopes of success in preventing the appearance of black-rot upon the berries and its disastrous consequences, by destroying it at its first appearance upon the leaves by means of the same remedies, the efficacy of which is recognized for combating the downy mildew. It is possible therefore, without increase of labor, to protect the vines from both diseases by the same treatment.

The hopes that by a proper use of sulphate of copper compounds we may find a successful treatment for black-rot certainly justify further careful experiments in their use.

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*Bull. 2, Bot. Division, p. 40, Plate VII, figs. *c*, *d*, *e*.

II.—NOTES UPON THE TREATMENT OF VINE DISEASES.

The preparations considered most likely to prove valuable as remedies in the treatment of mildew and black-rot were published last spring (1887) in the following circular form:

[Section of Vegetable Pathology.—Circular No. 3.]

Treatment of the downy mildew and black-rot of the grape.

To the vineyardists of the country:

Last year a circular was sent out by this Department recommending for trial certain remedies for the mildew and rot of the grape.

The results of experiments in 1886 have fully demonstrated the value of sulphate of copper ("blue-stone") over all other remedies in combating the mildew, and the results of many chemical analyses of the fruit and parts of vines treated with the copper compounds have clearly shown that there is no danger to health attending their application. The only precaution advised is not to apply them near (within fifteen days of) the vintage.

In their employment the fact must be kept in mind that their action is only preventive, therefore their application should be made early in the season, from the latter part of May to the end of June. Subsequent applications act only in so far as they serve to check the spread of the disease. The amount of the fluid compounds required to treat an acre of vines will depend largely upon the kind of pump and spraying nozzle used to apply them, and upon the extent of growth of the vines themselves; the amount may vary from 20 to 35 gallons.

The following are the formulæ of the remedies which so far have given the best results. An account of the results of trials you may make with one or more of them is earnestly desired, and a blank form for making up a report for the use of the Department in future publications will be sent you upon the receipt of the addressed postal card inclosed herewith.

LIQUID REMEDIES.

(1) *Simple solution of sulphate of copper.*—Dissolve 1 pound of pure sulphate of copper in 25 gallons of water. Spray the vines with a convenient force-pump having a nozzle of fine aperture. Less lasting in its effect than the next, as it is easily washed off by rains.

(2) *Eau celeste, blue water* (the "Audoynaud process").—Dissolve 1 pound of sulphate of copper in 3 or 4 gallons of warm water; when completely dissolved and the water has cooled, add 1 pint of commercial ammonia; then dilute to 22 gallons. The concentrated liquid should be kept in a keg or some wooden vessel and diluted when required for use. Apply the same as in the case of simple solutions.

The effects obtained by this preparation have been equal to those resulting from the use of the copper mixture of Gironde, and are said to be even more lasting.

(3) *Copper mixture of Gironde, Bordeaux mixture.*—Dissolve 16 pounds of sulphate of copper in 22 gallons of water; in another vessel slake 30 pounds of lime in 6 gallons of water. When the latter mixture has cooled, it is slowly poured into the copper solution, care being taken to mix the fluids thoroughly by constant stirring. It is well to have this compound prepared some days before it is required for use. It should be well stirred before applying. Some have reduced the ingredients to 2 pounds of sulphate of copper and 2 pounds of lime to 22 gallons of water, and have obtained good results.

Well made pumps with specially constructed nozzles are required for the application of this compound, unless we resort to the tedious and wasteful method of using brooms or wisps made of slender twigs, which are dipped into the compound and then switched right and left so as to spray the foliage, as directed in our circular of last season. The Vermorel apparatus, including reservoir, pump, and spraying nozzle, is well adapted for vineyard use, and is specially constructed for applying the various liquid preparations containing sulphate of copper.

POWDERS.

(4) *David's powder.*—Dissolve 4 pounds of sulphate of copper in the least possible amount of hot water, and slake 16 pounds of lime with the smallest quantity of water required. When the copper solution and the slaked lime are completely cooled, mix them together thoroughly; let the compound dry in the sun; crush and

sift. Apply with a sulphuring bellows furnished with an outside receptacle for the powder. The copper coming in contact with the leather will soon destroy it.

(5) *Sulphatine.*—Mix 2½ pounds of anhydrous sulphate of copper with 15 pounds of triturated sulphur and 10 pounds of air-slaked lime. Apply in the same manner as No. 4.

Both these powders (Nos. 4 and 5) ought to be procured from the manufacturer, prepared ready for use.

[NOTE.—It is very probable that Nos. 2, 3, 4, and 5 will be found equally serviceable in preventing potato "blight" and "rot." No. 5 should be employed when one has to contend with both the downy and powdery mildews. For apple scab we suggest trials with Nos. 2 and 3.]

The degree of success attending the use of these compounds will depend more or less (1) upon their careful preparation, (2) the time of the application, (3) the more or less intelligent manner in which they are applied, (4) the atmospheric conditions existing at the time or which may follow the applications, (5) the number of treatments made, and (6) the purity of the copper used.

In all cases where these remedies are tried a number of plants or vines should be left untreated to serve as "control experiments," for comparison with those treated.

Prices of materials (subject, of course, to variations):*

Sulphate of copper, pure:		
In quantity, by the barrel .... per pound..	$0.05 to	$0.06
At retail .... do....		.10
Anhydrous sulphate of copper .... do....		.28
Flowers of sulphur:		
Wholesale .... do....		.02½
Retail .... do....	.05 to	.06
Ammonia:		
Wholesale .... do....	.05 to	.06
Retail .... do....		.10
Lime .... per barrel (200 lbs.)..		1.05
Sulphatine, in quantity .... per pound..	.05 to	.06

NORMAN J. COLMAN,
Commissioner of Agriculture.

WASHINGTON, D. C., *April*, 1887.

The request that those trying any of the proposed remedies should report to the Department the character of the experiments made and the results obtained, met with generous response, nearly 200 reports being received. The substance of these reports will appear in the bulletin above referred to. A considerable diversity exists in the results obtained, which, for the most part, may be accounted for by the diversity in the manner of making the applications and especially by the varying climatic conditions in the different regions where the trials were made. In the hands of many the simple solution, eau celeste and the Bordeaux mixture gave excellent results for mildew, and quite a number claimed that one or the other of these preparations served to check the black-rot.

In almost all cases where these remedies were tried one or both of the diseases (black-rot and downy mildew) had already appeared at the time of the first applications. Understanding as we now do, the habits of the fungi causing these maladies, we know that our only hope is in the employment of *preventive* measures. If the sulphate of copper compounds are employed they must be used in season to

* Philadelphia quotations February, 1888: Flowers of sulphur, in barrels, 3 cents per pound; retail, 4 cents per pound. Powdered sulphur, in barrels, 3 cents per pound; retail, 4 cents per pound. Liver of sulphur, wholesale, 18½ cents per pound; retail, 25 cents per pound. Carbonate of soda, by the cask, 2 cents per pound; retail, 4 cents per pound. Carbonate of copper, 62½ cents per pound. Sulphate of copper, pure in crystals, 7 cents per pound. Sulphate of copper, anhydrous, 45 cents per pound. Liquid ammonia, in carboys, 7½ cents per pound; retail, 25 cents per pound. David's powder, per barrel (200 pounds), $12.50; 10 cents per pound. Sulphatine, per barrel (200 pounds), $16; 20 cents per pound.

act as preventives. We must cover the foliage and other parts of the vine subject to attack with a preparation which, upon drying, will adhere for a considerable time and prevent the germination of the fungus spores which may fall upon these parts. It is probable, also, that the nature of the cuticle may be so modified by the preparations used as to prevent the penetration of the germ tubes to the tissues within. In either case we must forestall the attacks by early applications, and to protect the later growths of shoots and foliage the applications must be several times repeated. In an ordinary season three applications will insure freedom from the mildew, but if the season prove a wet one a larger number may be necessary.

The methods and manner of making the applications are important considerations. A good apparatus for applying the liquids and powders is half the battle. When one has a vineyard of considerable size it is necessary to have spraying pumps or bellows which can be operated easily and quickly. The best form of sprayer for vineyard use is the portable arrangement designed for carrying on the back, knapsack fashion, having the reservoir and force-pump combined. Such an apparatus has recently been designed by Mr. Adam Weaber, of New Jersey. In form this resembles the Vigoroux sprayer, or the "l'Eclare" of Vermorel, of French manufacture, but the pump is constructed on different principles. With the better appliances of this class one man can easily spray from three to five acres of vines per day.

The spraying should be done thoroughly; that is, all the parts ought to be covered with the application, but care should be used not to *drench* the plants or vines. An excessive application is not only wasteful but liable to result in injury to the objects treated.

The amount of material used per acre will depend upon the season, extent of foliage growth, and the apparatus employed in applying it. In general, we would recommend for the liquids 25 gallons for the first, 35 for the second, and 45 for the third application.

The nozzle used should give a fine, mist like spray, or rather a cloud of vapor, which will envelop the plants, wetting them completely, but not so abundantly as to cause the liquids to drip from the leaves and shoots. Both the eddy chamber or cyclone nozzle, and Nixon's climax nozzle will yield a spray of the desired character. The latter is only suitable for clear liquids; when such compounds as the Bordeaux mixture are used, a nozzle with a degorger or device for clearing, like the Vermorel nozzle, is necessary. Improvements in our fungicidal appliances are greatly needed, and may be confidently looked for at no distant day.

As with liquids, so with powders, they should be distributed finely and evenly, their presence on the leaves, etc., after application being just perceptible. An excess of such powders as sulphatine (which is one of the best when properly applied) is very likely to injure the plants, particularly under a hot sunshine. Bellows furnished with outside receptacles for the powders are necessary, as the corrosive action of the powder will very soon destroy the leather if placed in contact.

As to the amount of powder to be used per acre, we would say for the first treatment 35 pounds, 45 or 50 pounds for the second, and 60 pounds for the third.

In respect to the remedies enumerated in the above circular, the use of the simple solution has in many instances resulted in injury to the foliage. As it is not advisable to reduce the percentage of sul-

phate of copper in the solution by the addition of more water, the simple solutions had best be discarded in treatments during the growing season.

Eau celeste also has, in the hands of some, injured the foliage materially, and a modification of the original formula is suggested in order to overcome this danger. In 2 gallons of hot water dissolve 1 pound sulphate of copper, in another vessel dissolve 2 pounds of ordinary carbonate of soda; mix the two solutions, and when all reaction has ceased add 1½ pints of liquid ammonia; when desired for use, dilute to 22 gallons.*

It is stated† that all danger of injury to the foliage from the first applications, made while the shoots are yet young and tender, may be entirely overcome by preparing the eau céleste for the first treatment in the following manner: Dissolve 1 pound sulphate of copper in a gallon of hot water, to this solution add liquid ammonia, a little at a time, until all the copper is precipitated; the liquid is then turbid and blue in color. Add two or three gallons of water and let stand to settle. Then pour off the clear liquid which contains sulphate of ammonia—the compound which causes the burning of the leaves. Then pour upon the precipitate left in the vessel just enough liquid ammonia to dissolve it. The result is a clear liquid of a beautiful deep blue color. When required for use dilute to 22 gallons.

Eau celeste prepared in the ordinary manner may be used without fear after the vines are in full foliage.

Considerable latitude is allowed in quantity of lime and copper sulphate in the Bordeaux mixture, but the amount of the latter ought not to fall below 4 per cent. The most recently recommended formula for preparation of this compound is 4 pounds of sulphate of copper, 2 pounds lime, 25 gallons water.‡ This reduces very much the cost of material, and the labor in applying is far less than when prepared according to the original formula, but some have found it to be inefficient.

III.—Potato blight and rot.

The value of eau celeste and the Bordeaux mixture in treating potato blight and rot (caused by *Phytophthora infestans*) has been frequently stated in France, and the very great need of discovering effective means for checking these diseases in this country was the occasion for preparing the following circular, which the Commissioner ordered to be printed and distributed:

[Section of Vegetable Pathology.—Circular No. 4.]

Treatment of the potato and tomato for the blight and rot.

SIR: In Circular No. 3 of this section, addressed to the vineyardists of the country, it was suggested that some of the preparations therein described might be found useful in preventing potato "blight" and "rot," this suggestion being made upon the knowledge of the fact that the fungus which causes the mildew of the vine is very similar in character to that which produces the diseases named above. The published evidence of experiments made in France, in 1886, in the treatment of potatoes and tomatoes for "blight" and "rot" with the Bordeaux mixture, gives additional weight to this subject and renders it highly probable that by the application

* Formula of M. Masson, Progrès Agricole, July, 1887.

† "Progrès Agricole et Viticole," April 29, 1888.

‡ Viala and Ferrouillat, "Manuel pratique pour le Traitement des Maladies de la Vigne," 2d ed., Mar., 1888, p. 27.

of preparations containing sulphate of copper we will be able to prevent, or at least to greatly diminish, the ravages of one of the worst enemies of the American farmer.

Directions for the preparation and application of the remedies thought most likely to prove successful are here presented, and it is earnestly recommended that they be given a thorough trial in order to demonstrate their supposed value.

LIQUIDS.

(1) *Eau celeste, blue water,* (the "Audoynaud process").—Dissolve 1 pound of sulphate of copper in 3 or 4 gallons of warm water; when completely dissolved and the water has cooled, add 1½ pints of commercial liquid ammonia, then dilute to 22 gallons. The concentrated liquid should be kept in a keg or some wooden vessel and diluted when required for use. Apply in clear weather with a suitable force-pump having a fine spraying nozzle, which will spray the plants thoroughly but not drench them. Make the first application when the plants are in bloom, the second a week or ten days later, and if the weather be such as will favor the development of "rot," a third, and perhaps a fourth application should follow within about the same intervals.

(2) *Copper mixture of Gironde, Bordeaux mixture.*—Dissolve 4 pounds of sulphate of copper in 16 gallons of water; in another vessel slake 4 pounds of lime in 6 gallons of water. When the latter mixture has cooled, it is slowly poured into the copper solution, care being taken to mix the fluids thoroughly by constant stirring. It is well to have this compound prepared some days before it is required for use. (The sulphate of copper ought to be purchased in a powdered state, as it dissolves with difficulty in the ordinary crystalline form.)

This liquid, slightly thickened because of the lime, may be applied with small brooms or wisps made of slender twigs, which are dipped into the compound and then switched over the plants so as to thoroughly spray the leaves. This method is wasteful and tedious, however, and where one has a considerable area to cover it would be economy to procure a spraying pump; the essential features of a good machine are ease and rapidity of application with economy of material.

Follow the same general directions in making the applications as are given under No. 1.

POWDERS.

(3) *Sulphatine* (the Estève process).—Mix 2 pounds of anhydrous sulphate of copper with 20 pounds of flowers of sulphur and 10 pounds of air-slaked lime.

(4) *Blight powder.*—Mix 3 pounds of anhydrous sulphate of copper with 97 pounds of flowers of sulphur.

This amount will be sufficient for one application to 5 acres of potato plants.

Powders possess the advantage over the liquid remedies of requiring less labor in transportation and of being more easy of application, consequently they will be preferred to the liquids, should they prove equally efficacious.

For applying the powders, which ought to be done when there is no wind and when the leaves are wet with dew or rain, the primitive arrangement, made of tin and constructed like a large pepper-box, or rather like an inverted funnel with fine wire gauze fastened over the lower end, and which, when filled with the powder, is held over the plants and shaken, is efficient and at the same time simple and inexpensive. Only enough of the powders, especially of the sulphatine, should be applied to be simply visible upon the leaves, as heavy doses may burn them.

Owing to the continual motion of the leaves of potato and tomato plants, by which both surfaces are liable to receive the spores of the fungus, the applications ought to cover both sides; this can best be accomplished by the use of a bellows with an extension nozzle, enabling the operator to direct the blast.

The degree of success attending the use of these compounds will depend more or less (1) upon their careful preparation, (2) the time of application, (3) the more or less intelligent manner in which they are applied, (4) the atmospheric condition existing at the time or which may follow the applications, (5) the number of treatments made, and (6) the purity of the lime and sulphate of copper used.

The following observations are essentially the same as those recently published by the French minister of agriculture, in a circular of similar import to this.

The experiments should be conducted in such a manner that the vines or plants treated and those left untreated (to serve as control experiments) may be comparable; they ought to be of the same variety, cultivated at the same time, and in all respects alike. The digging of the treated and untreated plants ought to be made simultaneously, for it has been proven that the tubers may be infected at the moment when they are taken from the ground, and that the chances of infection are

much greater in the early morning when the air and ground are damp, than later in the day when there is less moisture.

At the moment of digging, count the rotton tubers found in the soil and also those which are spotted only. The weights of the crops from the treated plants and from those not treated should be determined, and they should be preserved separately during the winter, but under identical conditions, for the purpose of learning if there be any difference between them in respect to infection.

Much may be accomplished in the prevention of potato-rot by renewal of seed, selection of varieties, and especially by planting only in light and well drained soils; also, perhaps, by following certain systems of cultivation; but the evidences we have of the serious losses occasioned by this disease throughout the potato growing regions of the United States render it imperative on the part of the Government to exercise all possible efforts for its prevention, and I respectfully recommend the immediate distribution of this circular, urging those who suffer directly from the ravages of the diseases named to experiment with the remedies and report to you the results obtained.

Respectfully,

F. LAMSON SCRIBNER,
Chief of Section.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

We have received no reports on the use of these remedies, and do not know that they have yet been tried, but we feel confident, however, that the remedies here enumerated, when properly made and applied, will prove effectual in preventing the ravages of the potato blight and rot.

IV.—FIELD OBSERVATIONS AND EXPERIMENTS.

In order to gain an accurate knowledge of habits of parasitic fungi and the ravages they produce it is absolutely necessary to carry on field investigations. The Department ought not to be obliged to depend upon volunteer reports for a knowledge of facts acquired through private experiments. Such reports, especially when treating of matters relating to fungi, are very likely to be misleading, owing to the imperfect knowledge generally possessed regarding this subject. And as to the matter of fungicides and the treatment of plant diseases, valuable conclusions can only be reached through field work carried on by some one familiar with the nature and habits of the fungi to be combated.

If this work be continued in a manner at all commensurate with its importance, and results obtained that shall meet the approval and confidence of the people the Department is designed to serve, it is necessary that Congress provide for a station which shall be under the absolute control of the Department for the needed field experiments. Office work is necessary, laboratory work must be done, but to attain practical results, and it is the practical conclusions which the farmer and fruit-grower are after, it is imperative that we go outside of the office and laboratory, and continue our studies and experiments in the field upon living plants. A station containing not less than 10 acres of land, located where a large variety of grains, vegetables, vines, and fruit trees and shrubs could be cultivated, is essential to the successful prosecution of the work required from this Section, and the development of its full power for usefulness. Here the effects of the parasites upon the host can be studied, inoculations of healthy plants made, and experiments carried on in the treatment of plant diseases. A small green-house is an important adjunct to such a station, and the work would be further facilitated by having in the

same location the laboratory for the microscopical studies and finer cultures.

Such a station, it is confidently expected, will be established at no distant day, and the results which then may be accomplished will be more in accord with the dignity of the position which this Department is designed to hold in its relations to American agriculture.

V.—SPECIAL SUBJECTS.

The plant diseases discussed in the following pages of this report have been made the subject of investigation either by myself or my assistants. Very little claim is made to originality, excepting, perhaps, in the manner of presentation; but it is hoped that this, together with the accompanying illustrations, will be found valuable and meet with public approval.

The chapters on the "Smut of Indian Corn," "Corn Rust," and the "Powdery mildew of the Gooseberry" were prepared by outside agents, employed for the purpose because of their having devoted particular attention to these subjects.

I wish here to express my thanks to my assistants for their constant diligence and ever-ready willingness to perform the duties assigned them, and especially to commend the valuable services rendered in the preparation of the following pages by the assistant, Mr. B. T. Galloway, and by Miss Effie A. Southworth.

1.—STRAWBERRY-LEAF BLIGHT.

Sphærella fragariæ, Sacc.

(Plate I.)

(*a*) GENERAL OBSERVATIONS.

There are a dozen or more fungi which infest the Strawberry plant, but the best known, and doubtless the one more injurious than all the others combined, is that which causes the disease we have here named Strawberry-leaf Blight. It has been called the "spot disease of strawberry leaves,"* "sun-burn," and often "strawberry rust."†

This disease is due to the attacks of a parasitic fungus which is common both in this country and in Europe. Here we have observed it from Maine in the East to California in the West, and complaints of its ravages have come to us from Florida and other sections of the South. It does not limit its attacks to the cultivated varieties, for we have frequently observed it on wild plants, and even on the common Cinquefoil, a plant botanically related to the Strawberry.

The Strawberry-leaf Blight fungus was first studied with the view of tracing its life history by two French mycologists, the Tulasne brothers, some twenty years ago. They figured and described the forms, determined by them under the name of *Stigmatea fragariæ*, and by this name the fungus was known in Europe until 1882, when it was transferred to the genus *Sphærella* by Saccardo.‡ The same

* Trelease, 2d Ann. Rept. Wis. Exper. St., 1885.

†We have attempted to restrict the term "rust" to those diseases caused by species of the family *Uredineæ*, and "spot" diseases, to such as result from the attacks of parasites included in the genus *Phyllosticta*, etc., adopting the term "blight" for those caused by species of *Ramularia*, *Cercospora*, etc.

‡Syllog. Fung., I, 505.

author described the summer stage of the fungus in 1879 as *Ramularia Tulasnei*, and in 1883 the same form was published by Mr. Charles H. Peck under the name of *Ramularia fragariæ*. This stage of the fungus has been made the subject of papers by several American botanists, but none have attempted to trace the development of the other forms in its life history.

(*b*) EXTERNAL CHARACTERS OF THE BLIGHT.

Very small, deep purple or red spots appearing on the upper surface of the leaves are the first symptoms of this disease. These spots rapidly increase in size, and at the same time their color changes from purple to reddish-brown; eventually they become gray or white in the center, so that they finally present a gray or white central area surrounded by a dark purple border, shading off towards the healthy tissues to reddish-brown. The spots vary in diameter from one-sixth to nearly one-fourth of an inch, but it very frequently happens that several contiguous spots coalesce and form large, irregular-shaped blotches. The bright color which these spots impart to the leaves renders the latter particularly conspicuous, and this appearance is familiar to every strawberry grower (Fig. *a*). The leaves badly affected soon turn brown, this discoloration usually beginning at their tips, and become shriveled and finally die. Similar spots to those above described sometimes appear on the calyx and on the stems supporting the young berries or fruit.

(*c*) EFFECTS AND LOSSES.

The effect of the Strawberry-leaf Blight on the foliage of the plants, even in mild cases, must be detrimental to the processes of assimilation; and when the attack is severe it results in the early destruction and death of the plants. If the fruiting stems or leaves of the calyx are attacked the young berries never reach maturity, or the fruit becomes shriveled and unfit for use.

The injury to strawberry culture resulting from this disease appears to have been on the increase during the past five or six years, to the general alarm of the growers of this fruit. No special efforts have been taken to learn the actual extent to which this fruit industry has suffered from the ravages of the blight, but enough has been learned to demonstrate its gravity. In some localities the injury effected has been comparatively slight, while in others entire plantations have been completely destroyed. It appears that the disease is most severe in the States of Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, Kansas, and Kentucky. In southern Illinois, where there are more strawberries grown than in any other section of the country, the blight is deemed one of the worst enemies with which the cultivator of this fruit has to contend, and the losses sustained are often very great. A Connecticut correspondent states that in one year he lost $1,500 on a field of 6 acres from the Strawberry Blight. In Louisiana and other Southern States the disease is less destructive. This is probably due to the fact that in this section the plants are renewed every year, allowing no opportunity for the fungus to gain a foot-hold.

The attacks may occur at any time during the growing season under the proper weather conditions. Those coming early, if severe, injure the immediate crop, while later attacks may entirely destroy the prospects of a crop the year following. It is the opinion of some strawberry growers that the heavier the crop the more likely are the

plants to be attacked by blight after the fruit is gathered. The death of the plants before the close of the season sometimes results from these late attacks.

Some varieties appear to be more subject to the disease than others, but we are unable, at this time, to make any classification based on their degree of susceptibility. The following varieties have been mentioned* as among those most subject to the disease: Downing, Wilson, Russel's Prolific, Big Bob, Bidwell, Captain Jack, Forest Rose, and Manchester; those notably free are Crescent, Windsor Chief, and Sharpless.

(*d*) CONDITIONS FAVORING THE DEVELOPMENT OF STRAWBERRY-LEAF BLIGHT.

Heat and moisture favor the development of Strawberry Blight, and at any time during the summer when the weather is hot and moist the plants are likely to be attacked. Heavy dews or rains are essential to infection, but the disease may continue its work of destruction during dry weather; and it not infrequently happens that it develops in its worst form in dry, hot weather succeeding a period of frequent or heavy rains. The fungus causing the malady is truly parasitic in its habits, and, except that the conditions which may favor its development be inimical to the plants, the health or vitality of the latter does not enter into consideration. Other things being equal, plants, however vigorous and well cared for, are no less subject to the blight than those in feeble health.

In respect to the soil, the disease is undoubtedly most severe when the land is heavy or wet and undrained. We have in mind an instance which will illustrate this point. A plantation of about 5 acres was bordered on one side by a brook, towards which the land gradually sloped. For about 60 feet back from the brook the soil was marshy and wet, while the remainder of the field was fairly well-drained. The plants on the narrow strip of wet land were much more severely diseased with blight than those on the comparatively dry soil adjoining. The effect was like that sometimes observed when two varieties—the one resistant and the other susceptible to the disease—grow side by side. In the present instance there were a number of varieties planted in rows running at right angles to the brook, so that the greater severity of the disease on the wet land could not be attributed to any difference in susceptibility of varieties. The disease in the locality here noted appeared early in May, some ten days after a heavy rain-fall which was succeeded by damp, cloudy weather.

A deep and thoroughly well drained soil will supply sufficient moisture to keep the strawberry plants in good condition, but not enough to favor excessive development of the blight.

(*e*) BOTANICAL CHARACTERS.

The fungus causing the Starwberry-leaf Blight, although of microscopic size, is a plant like the strawberry itself, and consists of a vegetative and a reproductive system; the former is the mycelium or plant body of the parasite; the latter comprises the spores or reproductive bodies and the organs supporting or containing them.

The mycelium.—The vegetative part of the fungus is made up of slender, thread-like tubes which grow between and sometimes into the cells of the host. These threads are colorless (sometimes tinted

* Trelease in Second Ann. Rept. Wisc. Agr. Exp. Station, p. 48.

brown), flexuose, often anastosmosing, septate, and varying in diameter from 1μ.5 to 3 μ (1μ=$\frac{1}{25000}$ of an inch). It is through the action of these mycelial threads on the cell contents of the host that the external characters of the disease, already noted, are produced.

Reproductive system.—The reproductive system of *Sphærella fragariæ* is quite complex, and although it has been studied very carefully it is not yet fully understood. From our examinations of the material at our disposal we have been able to determine three spore forms and possibly a fourth; the three of which we feel sure are conidia, spermatia, and ascospores. We are yet doubtful in regard to the pycnidia.

Conidia (Figs. *b* and *c*).—The best known and doubtless the most important reproductive bodies, economically considered, are the conidia. After the mycelium has grown for a time within the leaves and the light-colored central areas of the spots appear, the threads occupying this portion become massed together at frequent points just beneath the cuticle of either surface, and from these masses numerous short, colorless branches are sent out either through the stomata or ruptured cuticle, and it is upon their free ends that the earlier development of conidia takes place. The length of the branches varies a good deal, but usually ranges between 30μ and 50μ; they are sometimes composed of a simple elongated cell, but often they are divided by transverse septa into two to several cells. At a later period in the development of the fungus, conidia-bearing branches may arise from the perithecia, described below.

On the free ends of the branches the young conidia are developed, first as minute globose bodies, but, rapidly elongating, they soon appear as illustrated in Plate I, Fig. *b*. Sometimes a succession of spores, held together in a single series or chain by their contiguous ends, are formed upon a single stalk, and sometimes, though very rarely, two such series are developed from the apex of a common support. The free apex of the terminal conidium, whether it stands alone or forms one of a series, is obtuse and rounded; the other end and the extremities of those standing intermediate in a series are flattened at the points of attachment. Their length is from 20μ to 50μ, and they have a diameter of from 2.5μ to 4μ. Often only one-celled, they are frequently divided by transverse septa into two or three cells. They are colorless, like the stalks which support them, and are filled with a transparent, slightly granular fluid. The formation of these conidia continues throughout the summer, under favoring conditions of moisture and heat, and as they are exceedingly light and germinate readily in water, the rapid spread of the fungus and consequent disease over a plantation or section of country is easily understood. This stage of the fungus has been named *Ramularia fragariæ* by Charles H. Peck, and *Ramularia Tulasnei* by Saccardo.

At the approach of cold weather the formation of the conidia ceases, but the mycelium of the fungus remains alive in the tissues of the leaves, and in early spring a few warm days are sufficient to bring forth a new crop ready to spread infection at the first opportunity.

When the conidia are sown in water at a temperature of about 60° F., they will in a few hours send out slender germ tubes, which inincrease rapidly in length by continued apical growth. In forty-eight hours the germ tubes attain a length of many times that of the conidium from which they start, and are usually several times branched. Water is necessary to effect germination.

If, after a prolonged rain, a drop of water from a diseased leaf, or from an apparently healthy one growing close by, is examined with a good microscope, large numbers of conidia in various stages of germination will usually be seen. It is during such periods that the healthy leaves are infected; the germ tubes enter the leaf (either by directly penetrating the cuticle or through the "breathing pores"), and once within the tissue they may continue to grow independent of external circumstances.

Conidia sown on healthy leaves of pot-grown strawberry plants, which for three days following were kept constantly wet, produced the characteristic purple spots in about eighteen days. Similar sowings on leaves kept constantly dry were not infected, although the plants in both cases were cared for alike, except in the matter of moisture.

Repeated sowings of the conidia in solutions employed as fungicides were made. None germinated in a 1 per cent. solution of hyposulphite of soda, or in a one-fourth of 1 per cent. solution of sulphate of copper. A very small quantity of lime in water used in these experiments also checked the germination of the conidia.

Spermogonia.—During the autumn and early winter there is developed on the mycelium numerous round or ovoid bodies which, as they increase in size, break through the tissues of the leaf, appearing on the surface as minute black specks. Some of these bodies are the spermogonia, their interior being filled with spermatia. The spermatia have a length of 3μ, and are about three times as long as broad. They are produced in vast numbers and doubtless serve some important office in the economy of the fungus, but just what that office is has never been clearly demonstrated.*

Perithecia (Fig. *d*).—By far the larger number of the black bodies above mentioned are perithecia. They are the last to come to maturity, at the time the spermatia are most abundant their interior is filled with a clear mass of cells. They are usually somewhat larger (90μ to 130μ in diameter) than the spermogonia, and their outer walls are more nearly black and apparently thicker or firmer in texture. They are usually partially imbedded in the ruptured leaf-surface, but not infrequently they appear to be resting directly upon it. At the top of each there is a small opening or ostiolum which permits the contents to escape at maturity (Fig. *e*). If the perithecia be examined during the latter part of winter or early spring (they are almost always found abundantly on leaves destroyed by blight the previous year) the interior will be seen to be filled with numerous transparent sacs or asci attached to a thin layer of light-colored tissue resting on the botton wall (Fig. *e*). These sacs are about 50μ long and 10μ in diameter above, tapering below to a narrow base. Within them are formed the ascospores, usually eight in number in each sac (Fig. *f*). These are illustrated in Plate I, Fig. *g*, and are true reproductive bodies, designed, no doubt, to preserve the life of the fungus in special

*A fungus named *Septoria aciculosa*, often found associated with *Sphærella fragariæ*, has been thought by some to be the spermogonia of the latter, but its spores are often two-celled and they germinate without difficulty, contrary to the character of spermatia. Possibly it represents the pycnidial stage of the *Sphærella*, but this is very doubtful. *Septoria fragariæ* has also been thought by some to be the spermogonial stage of the *Sphærella*, but there is no longer any reason for supposing this to be the case. Another fungus (*Ascochyta fragariæ*), sometimes found associated with the *Sphærella*, has been regarded as its pycnidial form, but from our observations we can see no reason for accepting this view, although we have occasionally found this fungus on leaves destroyed by blight.

cases, but, as we have already seen, they are not essential to its perpetuation from one year to another. They are narrowly ovoid in shape, being more pointed below, and are divided into two cells by a transverse septum near the middle.*

Conidia-bearing stalks similar to those we have already described often grow in great numbers from the outer wall of the perithecium around the ostiolum, and like developments have been observed by us arising from similar parts of the spermogonia. These stalks produce conidia in every way like those which are formed in the early stages of the disease. By placing the old diseased leaves, upon which there are perithecia, in a moist atmosphere under a tumbler or bell jar the conidia-bearing stalks and conidia will grow from the latter in the greatest profusion.

From our studies of this fungus we conclude that its life history is limited to the developments above described: First, there is the mycelium, which endures throughout the year; second, the conidia, produced in the summer on short stalks arising from cushion-like masses of mycelium formed just beneath the cuticle. This stage appears to us to correspond to the pycnidial stage of the fungus of the black-rot of grapes, only, in this instance, the pycnidial walls are not developed, consequently the basidia and their spores are exposed; third, the spermagonia, which appear late in the season; and, fourth, the perithecia, with their asci and ascospores, found in early spring on leaves destroyed by the blight the previous year. The spore-forms are the summer conidia, the conidia which are produced on stalks that grow from the tops of the spermagonia and perithecia, the spermatia, and the ascospores.

The conidia are designed for the rapid propagation of the fungus, as shown by their great abundance and the ease with which they germinate. The ascospores, securely protected by the walls of the perithecium, are doubtless designed to perpetuate the fungus under conditions fatal to the life of the conidia.

(*f*) TREATMENT.

A knowledge of the habits of the fungus of Strawberry-leaf Blight shows us that the treatment of the disease must be preventive. The fungus, when once inside the leaf, can only be destroyed at the expense of the latter.

We can mitigate the evil and oftentimes wholly avoid it by pursuing special systems of culture. By annually renewing the settings and planting only in deep and thoroughly well drained soil loss from blight will seldom occur. Some have escaped the ravages of the disease by removing all the old leaves immediately after the fruit is harvested and cultivating the ground, at the same time adding some quick fertilizer. The easiest way to remove the leaves is to mow the beds, then rake the leaves together and burn them.

A simpler line of treatment, and one more likely to secure the desired result, is the application to the plants of some fungicide which will destroy or prevent the germination of the conidia falling upon the leaves. We have seen from our laboratory experiments, that these conidia will not germinate in very dilute solutions of hyposulphite of soda or sulphate of copper. It is a simple matter to apply similar solutions to the plants in the field, where it is only reasonable

*These ascospores are more elongated and rather more pointed at the narrow end than those figured by Tulasne, but they are certainly of the same species.

to suppose they will have a like action on the reproductive bodies in question.

Prepare the solution of hyposulphite of soda by dissolving 1 pound of the hyposulphite in 10 gallons of water. Apply with a convenient force-pump having a spraying nozzle of fine aperture.

The action of this remedy is immediate, hence it is necessary to apply it frequently during the season.

The sulphate of copper solution with carbonate of soda (described on page 331), or the following solution of ammonia calcarbonate of copper may be useful in treating this disease: In 1 quart of liquid ammonia dissolve 3 ounces of carbonate of copper, then dilute to 20 gallons.

These preparations of copper salts should be applied in the same manner as the hyposulphite of soda solution. They adhere very strongly to the foliage, and as the copper they contain dissolves very slowly their preventive action against the fungus lasts for a long time.

A solution of sulphide of potassium or "liver of sulphur" has been employed in combating the blight of the strawberry with encouraging results. Mr. R. E. Buffum, of the University of Virginia, writes:

> I sprinkled the strawberry plants with a solution made by dissolving 1 ounce of sulphide potassium in 8 gallons of water, repeating the operation several times before the berries ripened. This, I think, had a beneficial effect, as there was certainly a marked decrease in the amount of blight.

Prof. J. C. Arthur states in the Sixth Annual Report of the New York Agricultural Experiment Station, page 351, that—

> A part of a bed of Sharpless strawberries was sprayed four times with a solution of sulphide of potassium (one-half ounce to 1 gallon of water) with the object of holding in check the spotting of the leaves, due to the fungus *Ramularia Tulasnei*, often described as "sun-burn." The object sought was attained, as that part of the bed took on a more vigorous growth and showed fewer spotted leaves than the remainder. In fact, the difference between the sprayed and unsprayed portions was so marked that it seems unsafe to ascribe it wholly to the fungicide, it being better to content one's self with the strong indication that the sulphide is likely to prove a serviceable preventive of this disease, and to leave the question of its full efficiency to be determined by future trials.

As the value of whatever remedy may be employed, depends entirely upon its power to *prevent* the germination of the conidia of the fungus, the necessity of making the applications early is obvious.

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2.—Apple Scab.

Fusicladium dendriticum.

(Plate II.)

(*a*) GENERAL OBSERVATIONS.

The disease of the apple caused by the fungus parasite *Fusicladium dendriticum*, has long been known to growers of this fruit as "Apple Scab." Less frequently we hear it spoken of as "black spot," or simply spot disease of the apple, or, when on the foliage, "leaf blight" or "leaf mildew." It has been known to botanists for a long time and has received many Latin names, but the one here adopted has been generally employed by mycologists since 1869.

The distribution of this disease is co-extensive with the cultivation of the fruit which it attacks, although there may be a few favored localities where it has not yet appeared. Throughout the Eastern and Central States one is almost certain to find it in every orchard, and on the Pacific slope in California it is also frequent. For more than fifty years it has been known in Europe. It has become a serious pest in Australia, and we now possess reports of its presence in New Zealand.

Closely allied species, or, perhaps, only forms of the Apple Scab fungus, infest our native thorn trees and other natives botanically related to the apple.

A fungus of such economic importance has, as may well be supposed, received much attention from our horticultural writers, and numerous papers relating to it are scattered through our horticultural journals and the reports of horticultural and agricultural societies. Some of the more important of these are mentioned below.

For a long time the fungus on the leaf causing the "leaf blight" or "leaf mildew" and that on the fruit causing the "scab" were regarded as distinct species. It was suggested by Prof. M. C. Cooke in 1873 that they were identical, and subsequent investigations have fully confirmed this view.

(*b*) EXTERNAL CHARACTERS OF APPLE SCAB.

On the leaves.—There first appear very small olive-green spots with a definite and rounded outline (Fig. 2). As these increase in size, their surface assumes a velvety appearance and their borders

become more or less irregular. The older spots vary from one-eighth to one-half an inch in diameter; frequently two or more spots may run together, forming large irregular blotches. Although most frequent on the upper surface of the leaf the spots sometimes appear on the under side, and the fungus often extends to the leaf petioles and young twigs, covering these parts with its dark, olive-green, velvety growth. When examined closely with a hand lens the spots on the leaves are seen to be made up of irregular threads radiating in all directions from a common center.

On the fruit (Fig 1).—The development of the spots on the fruit is similar to that which takes place on the foliage. They start from a center of infection and usually preserve a more or less rounded outline. As they increase in size the ruptured cuticle appears as a light-colored ring around their borders, and frequently flakes of the cuticle adhering to their surfaces imparts to them a more or less grayish appearance. The greatest vigor of the fungus is towards the margins of the spots, the central portion sometimes dying, and the apple beneath, in its efforts to recover from the disease, forms a corky layer which appears as a roughened, russet-like surface.

(c) EFFECTS AND LOSSES.

Through the action of the parasite on the leaves there is an unequal development in the two surfaces, causing a greater or less distortion of these organs and, when badly affected, their power of assimilation is destroyed. Its injury to the twigs or young shoots, when these are attacked, is often quite serious in its character. It is on the fruit, however, where it produces the dark olive-green or black spots so well known to every orchardist as "Apple Scab," that the fungus causes the greatest injury. At no period of its growth is the apple exempt from the attacks of this parasite, but the most damage is occasioned when the fruit is infested early in the season. Sometimes, when the apples are no larger than peas, the fungus of the scab may be found upon them, not infrequently enveloping their entire surface, and practically checking all further development. When less severely attacked the apples may continue to grow, even to maturity, but the result is knobby, misshapen fruit of inferior quality. If the attack is made towards the close of the season the fruit may attain its full proportions and quality of flavor, but the spots, disfiguring its surface, render it unsightly and depreciate its market value.

Under ordinary circumstances there are some varieties which escape the scab, but in some seasons, however, it respects neither condition of soil, mode of culture, nor variety of fruit.

The varieties reported to be comparatively free from the disease are the Russets, Ben Davis, Winesap, Willow Twig, Jonathan, Rawle's Janet, Smith's Cider, Maiden's Blush, Grimes' Golden, York Imperial, R. I. Greening, Sops of Wine, Duchess.

Those especially subject to its attacks are White Winter Pearmain, Huntsman, Northern Spy, Early Harvest, Carolina Red June, Fameuse, Baldwin, Hass, etc.

It must be said, however, that varieties notably free from disease in one section when grown in some other locality more or less remote may scab badly.

The Bellflower comes into the markets in Washington nearly free from scab some seasons, while in others it is very badly affected, and

the same fact has been observed in regard to some of the varieties named in both the above lists.

In response to letters sent out by this section relative to the prevalence of "scab," a number of prominent horticulturists in different sections of the country have furnished interesting information relative to the extent of the injury occasioned by the disease, varieties affected, etc. In several States the extent of loss is reported to amount to fully one-half of the crop, while reports from other States place the annual loss at from one-fourth to one-sixth of the crop.

A. J. Hammond, secretary of the Illinois Horticultural Society, estimates the loss from this cause in each county in his State at 20,000 bushels, which, at 20 cents per bushel, gives a loss of $4,000 per county, or about $400,000 for the entire State. Secretary Goodman, of Missouri, estimates the loss in his State to be one-half the crop. Secretary Brackett, of Kansas, places the annual loss in that State, one year with another, at one-fourth of the crop. Mr. Ragan, secretary of American Pomological Society, places the annual loss from Apple scab in Indiana, at about one-sixth of the crop.

Under date of November 11, 1886, Mr. Charles S. Pope, president of the Maine Pomological Society, writes as follows:

> Five years ago our individual loss from this disease was at least $1,000, and this year we hear of injury to the apple crop from this cause in many parts of the State. The apples begin to show the "scab" before they are half-grown, and frequently all growth is stopped, and the fruit shrivels and becomes worthless. If not badly affected the fruit makes fair growth, but it is so much injured that the apples begin to decay under the spots early in the season.
>
> Perhaps you may think that I exaggerated a little when I stated that we lost $1,000 in one season from this disease, but I will show you how I arrived at my conclusions. In 1881 we harvested nearly 3,000 bushels of Baldwins, of which about 2,000 bushels were so badly affected that we kept them in separate bins, and not over half of them were suitable for No. 1 apples; the diseased apples were sold for 25 cents less per barrel than the best ones. Now, the affected apples were not more than half-grown; in fact, the apples on many trees were so small that we shook them off and threw them in with the cider apples. We sold the 2,000 bushels of affected apples for about $1,200; had they been free from "scab" and attained full size, or 4,000 bushels, they would have been worth from $3,000 to $3,500. With this estimate the loss was more than $2,000. I call to mind one season when we lost more than half our crop about midwinter by rotting. The apples began rotting under the "scab" spots and eventually the fruit entirely decayed.

(*d*) THE CONDITIONS FAVORING THE DEVELOPMENT OF THE SCAB.

The fungus of the Apple Scab appears to be retarded in its development by the heat of summer. Its most rapid growth takes place during moist, cool weather, such as usually prevails during the early months of spring or autumn. It may be observed that spots which during the hot summer months remain brown, at the approach of cool weather assume the olive-green, velvety appearance indicating a renewed activity on the part of the fungus. The parasite doubtless retains its vitality through the winter, both on the twigs in the orchard and on the fruit which it infests. We have seen specimens of the latter in midwinter in the markets of Washington covered with spots on which the fungus was in a most flourishing condition. From the ease with which we know it can be propagated to healthy fruit, and from the appearance of apples in the public markets in the winter and spring months, we believe that the disease may spread after the fruit has been harvested and placed in storage. It is a well-known fact that apples, after being gathered and stored, undergo a sweating process, and if healthy and diseased fruit are in contact during this period, infection of the former is very likely to follow.

It is also well known that the "scab" fungus is most severe in its attacks in seasons when damp, cold weather prevails at the time the fruit is forming. In the spring of 1885 the young fruit was closely watched for the first appearance of the "scab" by my assistant, Mr. Galloway, then at Columbia, Mo. It was noted that at the time the young apples were about the size of peas a period of cold, damp weather set in. In a few days many of the varieties showed plainly the minute black specks which mark the first appearance of the fungus; later these developed into the well-known "scab" spots. The spring of 1886, in the same locality, was very dry and warm, and there was a marked absence of the *Fusicladium*.

The character of the soil appears to have little influence over the disease, although in heavy soils, particularly where the subsoil is wet or poorly drained, it is naturally more prevalent than in light or well drained lands. A damp, cool atmosphere rather than an excess of moisture with heat appears to be most favorable for the development of this malady.

(*e*) BOTANICAL CHARACTERS.

Mycelium.—In thin sections the mycelium or plant body of the fungus—the vegetative portion—appears like a dense mass of tissue composed of dark brown-walled cells. It does not penetrate the tissues of the host, but grows between the cuticle and the epidermis. It sometimes occupies the cells of the epidermis, especially in the fruit, and not infrequently the epidermal layer is entirely destroyed by it, the fungus resting directly on the tissues beneath. Its effects are confined to a few underlying layers of cells. These are shrunken and have their walls and contents browned. The growth of the fungus soon distends and breaks the epidermis. From the exposed surface there arise short (40μ to 50μ) upright brown threads upon which the reproductive bodies or spores are borne (Fig. 3).

Reproductive bodies.—The spores (Fig. 4) are of the same color as the upright threads or stalks supporting them. They are usually oval in outline, though not infrequently egg-shaped or pear-shaped, and vary a good deal in size. Their average dimensions are 10μ by 20μ. Generally simple or one-celled, they are occasionally divided into two cells by a transverse wall or septum. Aside from the power of reproduction which the fungus possesses in these spores, it appears that the individual cells composing the plant body of the parasite may serve a similar purpose. These, under favoring conditions, will push out germ tubes, if we may so apply this term here, which develop into new individuals of the species. This method of reproduction may be roughly compared to that by root cuttings in some of the higher plants.

Germination of spores.—The spores germinate rapidly in water, or even in an atmosphere saturated with moisture. The surface of many scab spots on the White Winter Pearmain, purchased in the Washington market in December, were found to be covered with vast numbers of germinating spores, the filamentous germ tubes everywhere covering the spots with a vigorous growth. The appearance of spores in germination is illustrated in Fig. 4, Plate II.

The germ tubes are rather thick, nearly of the same color as the spore, and frequently divided by cross-walls or septa. When the free end of the germ tube comes in contact with any obstruction it usually

thickens and pushes out lateral or side branches from the swollen points.

A number of experiments have been made in the laboratory in germinating the spores of *Fusicladium* in various solutions and at different temperatures. It was found that they germinated most readily in pure water at a temperature of about 50° F., the time required usually being about eight hours. In thirty hours the germ tubes attained a length many times that of the spore. Under certain conditions, not well understood, the filaments developed secondary spores at their tips, and these in turn germinated like the original spore.

When subjected to a comparatively high degree of temperature, and all water removed, growth in the germinating spores ceased, but was renewed at once upon being restored to the favoring conditions of heat and moisture, even after the lapse of four or five days.

Repeated sowings of the spores made in solutions of sulphate of copper of various strengths, showed that a one-fourth of 1 per cent. solution would effectually prevent germination; in a one-eighth of 1 per cent. solution about 10 per cent. of the spores germinated, but they made only a feeble growth.

In the study of the diseased White Winter Pearmain, mentioned above, there was unmistakable evidence of the penetration of the cuticle by the germ tubes. As an experiment, some germinating spores were sown on the healthy surface of one of the apples and then kept moist under a bell-jar. In ten days it was found that the germ tubes had penetrated the cuticle in several places, and made a considerable growth in the cells of the epidermis. This penetration was evidently effected by a dissolving or eating away of the cuticle through some corrosive action on the part of the germ tubes. The possibility of infection of healthy fruit from that which is diseased in the same barrel thus appears to be evident.

This reproduction by the spores, joined with the independent growths which may arise from the individual cells of the plant body, afford ample provision for the propagation of the fungus. No other form of this fungus is known than that which we see in the "scab" of the fruit or "mildew" of the leaf, nor does any other form seem to be necessary for the continued existence of the species. The fungus is doubtless perennial, living on the fallen leaves, but more especially on the fruit and young shoots during the winter, and the low temperature at which the spore-formation takes place, insures its early propagation and dissemination in the spring.

(*f*) TREATMENT.

The fungus of the Apple Scab does not penetrate into the tissues of the host, and very early in its development it is wholly exposed to any application which may be made to destroy it. It appears, however, that the vegetative portion or plant body of this, as well as of many other fungi, is very resistant to the action of chemical re-agents quite as much or more so than are the tissues of the leaf or apple upon which it grows. We can scarcely hope, therefore, to accomplish its destruction, unless it be the growths infesting the young shoots and the scales of buds. Before the latter expand in the spring much stronger solutions can be applied than it is possible to use later in the season, and it is at this period that the warfare against this fungus should begin. It has been observed that the germination of the spores is

wholly prevented in very dilute solutions of sulphate of copper, and our chief dependence in combating this disease appears to rest upon this fact—the possibility of preventing the germination of the spores where they can do harm. A practical treatment has been discovered by which we may prevent the germination of the spores of the downy mildew of the grape-vine by applying various solutions of sulphate of copper to the surfaces of the leaves upon which the spores of the fungus fall. It is doubtless equally practical to accomplish by a similar treatment, a like result in the case of the *Fusicladium* of the apple. Experiments already made with the sulphate of copper solutions indicate that they will, when properly applied, at once check the "scab." Further and more systematically conducted experiments are required in order to determine fully what preparation is most efficacious, at what season it is best to make the applications, and the strength to which the solutions must be limited. Where eau celeste, prepared according to the original formula, has been tried it has severely burned and injured the foliage. This preparation may be rendered less caustic by the addition of ordinary carbonate of soda, or by being prepared as directed on page 331.

Another and more simple modification of the eau celeste is prepared by dissolving in 1 quart of liquid ammonia 4 to 6 ounces of carbonate of copper, then dilute with water to 25 gallons. The ammonia and carbonate of copper solution may be kept in a bottle and diluted when required for use at the rate of about 1 ounce of the solution to the gallon of water. Those who have used this preparation on the grape-vine say it is perfectly harmless to the foliage and is as efficacious against mildew as eau celeste. It is simple and easily prepared and is very strongly adherent to the foliage.

Simple solutions of sulphate of copper ought not to be employed during the growing season as their use is almost certain to result in injury to the foliage. The Bordeaux mixture (see page 328) may be used at any time without fear of injury.

Using one or the other of the above preparations, the following course of treatment is suggested:

(1) In early spring, before the buds have commenced to expand, spray the trees thoroughly with a solution of sulphate of iron, using 4 pounds of the iron sulphate to 4 gallons of water.

(2) As soon as the fruit has set, apply the Bordeaux mixture or one of the modified preparations of eau celeste.

(3) If the weather should be such as to favor the development of the "scab" fungus, a third application should be made two or three weeks after the second, using the same materials.

In addition to the effect that these applications may have on the development of the fungus, they will doubtless serve to keep off many insect pests.

In storing the fruit for winter, especial care should be taken to separate all the apples showing any signs of the scab from those which are smooth and healthy, and they should all be kept in rooms or cellars free from moisture.

The Nixon's pumps, or Field's force-pump, are good appliances for spraying the simple solutions and eau celeste, and, substituting the nozzles furnished with these for the Vermorel nozzle, they may be employed to apply the Bordeaux mixture. In employing solutions containing sulphate of copper it is essential that the pumps be made of copper and the valves should be made of rubber; if the latter are of leather they ought to be oiled frequently during the applications.

Iron is quickly corroded and leather soon destroyed by the caustic action of the copper salt.

Experiments have been made in treating the *Fusicladium* of the apple with a solution of hyposulphite of soda, 1 pound of the sulphite to 10 gallons of water, by Mr. E. S. Goff, of the New York Agricultural Experiment Station. He made applications to one tree only, a Siberian crab, which had for several years been so much affected with the fungus as to render the fruit entirely unfit for use. Applications were made to one-half of this tree May 5, 9, and 15. The result was that on the sprayed part of the tree the per cent. of uninjured fruit was double that on the unsprayed part, while the per cent. of third quality or much injured fruit was one-half less.

The year following the same tree was again treated, four applications being made, viz, April 22, May 6, 10, 17. The strength of the solutions in the first three applications was 1 pound hyposulphite to 10 gallons water; in the fourth the solution was reduced one-half. The part of the tree sprayed bore a fair crop of medium-sized fruit, while on the unsprayed side the apples were so affected by the fungus that none matured.

This remedy is cheap and easy of application, and, should it generally prove to be as effective as in the case here cited, its value can scarcely be over-estimated. It does not possess the lasting preventive qualities of the preparations of sulphate of copper, as its action is immediate, and, other things being equal, preference should be given to the copper compounds.

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Wallroth: Flora cryptogamica Germanica; 1833; Sub. *Cladosporium dendriticum.*

3.—BITTER-ROT OF APPLES.

Glœosporium fructigenum, Berk.?

(Plate III.)

(a) GENERAL REMARKS, EXTENT, AND SEVERITY.

During the past year a number of fruit-growers in the Southwest have complained of a rot of the Apple which was seriously affecting their crops. In parts of Arkansas the disease was said to be very injurious, frequently causing the entire destruction of the fruit.

Mr. J. W. Beach, a successful fruit-grower of Batavia, Boone County, Ark., relates his experience with this disease as follows:

> I came to this county in 1884, and that season there were four trees in my old orchard affected, two of which were Fameuse. The man from whom I purchased my place told me that the Fameuse had always been subject to the rot. For the last three years the disease has steadily increased, so that this year (1887) my old orchard of 75 trees will not yield 25 bushels of sound apples. I have talked with a great many orchardists in regard to the trouble, and they all agree in the opinion that the old orchards are the most affected. I have lately visited fine orchards of hundreds of trees, but in no case did I find the fruit perfect; all were more or less diseased.

From the information received it appears that the rot usually begins early in the summer and increases as the season advances. When once affected the fruit never recovers, but continues to decay until completely destroyed.

The rot may develop after the apples are harvested and stored for the winter, and also spread from the diseased to the healthy fruit by contact. All varieties are alike attacked, and the development of the malady is not influenced by the system of cultivation pursued or by the character of the soil. At Denison, Tex., our attention was called to this disease through the large amount of fruit destroyed by it. It begun while the apples were yet upon the tree, and in some cases the brown patches on the fruit suggested the idea that they might result from sun scald, but an examination of the diseased tissues, as well as subsequent developments, point to another cause.

This rot is caused by a fungus that belongs to a group the members of which are frequently quite destructive, one species causing the socalled anthracnose of the vine, while another attacks the raspberry and blackberry. The members of the group as a whole, are known to botanists as *Hyalosporæ,* and the species which causes the Apple rot we are describing, we think is *Gleosporium fructigenum,* Berk. So far as we have been able to discover, the first account of this fungus was published in the Gardener's Chronicle by the Rev. M. J. Berkley, more than thirty years ago.* Several subsequent writers on plant diseases have briefly referred to it.

Serious and wide-spread as this disease seems to be in certain parts of the United States, we do not find in the works of our mycologists any record of the fungus that causes it.

(b) EXTERNAL CHARACTERS.

The affected apple at first shows one or more black or, usually, brownish spots on any part of the surface; as these gradually enlarge their shape becomes more or less circular and their borders somewhat

* Gardener's Chronicle, 1856, page 245.

sharply defined. Sometimes the spots coalesce or run together, and in this manner the entire apple is soon affected. Toward the center of the diseased spot there is usually a very dark, frequently almost black, discoloration.

Upon close examination it is seen that the darker portions are studded with minute black points, which are slightly raised above the surrounding tissue, imparting to their surfaces a somewhat roughened appearance; occasionally these points are arranged in circles or grouped in little clusters.

On cutting through a diseased apple while the spots are small it is seen that the decaying tissue extends to quite a distance into the fruit, and as the growth of the fungus continues the entire apple soon becomes a soft, yellowish-brown mass.

(c) BOTANICAL CHARACTERS OF THE FUNGUS.

The body of the parasite, or the mycelium, consists of slender threads, which push their way through the tissue of the fruit and destroy the parts with which they come in contact. These threads vary in size and color. At first they are nearly transparent; later, however, they become darker, and when old they are usually brownish-black and somewhat thickened.

Frequently the thicker tubes send out lateral branches, which are at first colorless. These are divided by more or less frequent transverse partitions or septa, and soon assume the usual brownish color. The walls of the tubes are constricted at the septa, so that when the latter are roughly handled they frequently break apart at these points. In the process of growth the mycelial threads become thickly matted and interlaced at certain points, and as these mats become more compact they gradually take a more or less globose shape. Transverse sections through a portion of a diseased spot will reveal these little rounded masses in all stages of development.

Their formation begins at a point some distance beneath the epidermis, and as they continue to enlarge they finally rupture the latter and appear on the surface in the form of the minute black specks already described. A thin transverse section through one of the mature black pustules shows their structure. With the aid of the microscope it is seen that they consist, for the most part, of compact, dark-colored, many-septate threads, which are arranged with their ends pointing towards or frequently protruding through the ruptured cuticle. Before the cuticle is ruptured this arrangement is not so apparent as the mass at this time has a rounded form. When the cuticle is torn, however, the hitherto globose mass spreads out and becomes somewhat fan-shaped above (see Fig 2).

Upon the tips of the closely-compacted threads spores, or reproductive bodies, are borne (Fig. 3). These are colorless, or nearly so, and somewhat variable in shape; usually, however, they are more or less cylindrical, rounded at each end, and, occasionally, somewhat curved (Fig. 3, B).

Each thread develops a single spore, but the former are so thickly compacted that an immense number of the latter are developed in each pustule. When sown in water the spores germinate within ten hours by sending out one or more rather thickish germ tubes (Fig. 5). When first sown there are usually no signs of nuclei in the spores. Just before germination, however, nuclei (or vacuoles) appear, and the contents of the spore become granular.

The germ tubes continue to increase in length without further change for about twenty hours, when there appear upon the free ends slight swellings, which gradually enlarge and become more or less globular and dark colored. When full grown these bodies are about 8μ in diameter, and soon after attaining this size they germinate in a manner similar to that of the original spore.

The tubes from these secondary spores continue growing and ultimately develop the same kind of bodies from which they were derived, and this process continues as long as moisture and heat are furnished (Fig. 4).

On the 18th of November, 1887, spores taken from a diseased apple were sown in several places upon the cut surface of a healthy Winesap. Spores were also sown at the same time upon the uninjured surface of the same specimen. Six days later the brown spots where the spores were sown upon the cut surface were one-half an inch in diameter, while no effect whatever was produced where the sowings were made upon the uninjured surface. These experiments were repeated a number of times, but in no case did we succeed in infecting the apple where the spores were sown upon the uninjured surface.

Infection was readily secured by inserting a knife blade first in a diseased apple and then in a healthy one. About eight days after the spores are sown the little black pustules usually appear, showing that reproductive bodies have again been formed.

There is frequently found at the base of the spore-bearing threads a rather thick and dark walled cavity (Fig. 2), which, as seen in a cross-section, shows a clear zone completely filled with minute, colorless, oblong bodies borne upon slender, transparent basidia or stalks that spring from the surrounding walls.

These sacs or conceptacles are called pycnidia, a name determined by their contents. What may be their rôle in the economy of the fungus is a matter of question. It is probable, however, that they aid in some way in the propagation of the fungus. The spore-bearing threads first described, spring directly from the walls of the pycnidia, and it is probable that they live through the winter in the decaying fruit, as we have found them in abundance in January, and at this date they developed a great number of spores when placed in a warm, moist atmosphere.

From the foregoing account of the disease and its cause, it will be readily understood that we have a dangerous foe to contend with, but with our present limited knowledge of its habits it is impossible to suggest means of combating it.

4.—The Rust of Beets.

Uromyces betæ, Pers.

(Plate III.)

(*a*) GENERAL OBSERVATIONS.

This disease is not a new one to other countries, and the life history of the parasite causing it was followed through by Kühn as early as 1869, while the summer form was described as *Uredo betæ* by Persoon, and the winter stage as *Uromyces betæ* by Tulasne earlier than this. The discovery of the æcidio-stage is due to Kühn

(1869). It is a well-known malady both in France and Germany, but is not serious enough to call forth much notice in the agricultural journals. This is probably due to the fact that it occurs only in isolated places and is easily controlled; for it attacks both the sugar and fodder beets, and the diseased leaves soon turn yellow or brown* and are not even good for fodder. It is supposed that it somewhat diminishes the amount of sugar produced in the countries where it exists; and a French scientific work† of 1878 states that it had been on the increase for several years.

(*b*) THE DISEASE IN CALIFORNIA.‡

In September, 1887, at Orange, in the southern part of California, the leaves of the cultivated Beet were found attacked by this Beet rust. The infested leaves were thickly dotted with powdery, round or oval, raised, reddish-brown spots, surrounded by a white rim formed of the ruptured epidermis, and varying in size from mere points, scarcely visible to the naked eye, to spots slightly over a millimeter in diameter. They were irregularly distributed over both surfaces of the leaf, sometimes occurring exactly opposite each other. Some of the spots were surrounded by a small area of dead tissue.

Dr. Byron D. Halsted § states that he found this rust at Santa Barbara, where it "was making much trouble for the market gardeners. In some places every leaf of the plant was badly infested and whole rows of beets were dwarfed and discolored by the parasite. The pest was found in its worst form on the escaped plants which in some places almost cover the moist low ground."

(*c*) MICROSCOPICAL CHARACTERS OF THE FUNGUS OF BEET RUST.

Upon examination with the microscope these effects were found to be caused by a fungus belonging to the family *Uredineæ*. Investigations of many members of this group by various observers have demonstrated that they are polymorphic, *i. e.*, possessing two or more forms of spores or reproductive bodies, and these forms may or may not develop upon different hosts. In the case of the fungus of the rust in question, all these forms are found upon the same host, each kind having a particular time of the year for its appearance, following a regular succession in development.

Æcidio-stage.—The form which occurs earliest is the æcidio-stage. This has two kinds of receptacles, the æcidia and the spermogonia, the latter appearing slightly earlier than the former. These forms appear in the spring upon the leaves and petioles, developing just beneath the cuticle. They at first form raised places upon their surfaces. The epidermis is soon ruptured and the spermogonia and æcidia are exposed, appearing as clusters of spores surrounded by a white envelope having the shape of a bowl or cup. The æcidiospores are orange-yellow, arranged in chains, and set so close together that, by mutual pressure, they have a polygonal form. These æcidiospores are developed from short, upright basidia at the base of the cup. When brought upon the surface of the leaf, under favorable

* Frank, Die Krankheiten der Pflanzen.

† Jubainville et Vesque.

‡ Its presence in California is noted by Rev. J. E. Vize, in Grevillea, Vol. V, (1876-'77), p. 110.

§ Bulletin from the botanical department of the Iowa State Agricultural College, 1888, p. 115.

conditions, they give rise to germinating filaments which enter the leaf through the stomata and form a mycelium in its tissues. In its growth this mycelium winds through the intercellular spaces (Plate III, Fig. 10), and obtains sufficient food for its development by means of haustoria which it sends into the cells.*

Uredo-stage.—At a definite period these mycelium threads form compact masses in certain places beneath the epidermis, and from these masses arise short, upright hyphæ or basidia, each of which bears a single spore upon the end (Plate III, Fig. 10). The spores, increasing in number and size, rupture the epidermis (Fig. 10 *b*), and when ripe escape by falling from their basidia, which, in this case, are known as pedicels (Fig. 10 *d d*). This is the summer or uredo form of the fungus, and its external appearance has been already described.

The uredospores (Fig. 11) are round or ovate, dark yellow, with a somewhat thickened wall and an echinulate surface, upon which one or two bright places may be seen. These bright spots are caused by perforations in the endospore or inner layer of the wall, and it is through these perforations that the young, growing hypha protrudes in germination (Fig. 11 *a*).

Teleuto-stage.—These germ filaments bore through the epidermis* and form a mycelium like that developed from the æcidiospores in form, manner of growth, and function. The uredospores are produced in this manner for several generations, but as autumn advances spores of another character appear among them. This third form is also unicellular, but darker in color and thicker walled than either of the others. It has a smooth surface, and opposite to the attachment of the pedicel there is a thin place in the wall that affords a point of least resistance to the germinating hypha. When ripe these spores fall off, carrying with them the pedicels which become detached from the stoma beneath. The name teleutospores is applied to this third form, and they may occur mingled with the uredospores or form independent spots. In the latter case they occur upon the petiole.† The teleutospores are the resting or winter spores of the fungus, and, although appearing in the fall, they do not germinate until the following spring after a winter period of rest. The germinating tube pushes through the thin place in the wall opposite the point of attachment of the pedicel and forms a short branched hypha or promycelium. From the end of each branch small buds or sporidia are cut off by a special process. These are capable of germinating and producing a mycelium in the plant tissues, and this in turn reproduces the spermogonia and æcidia, thus completing the alternation of generations.

It will be seen that the life history of this fungus is the same as that of other *Uredineæ*, but it differs from the other genera of this group in that its winter spores are unicellular. It closely resembles *Uromyces rumicum*, found upon sorrel, but, so far as known, it has never been found upon any host but the Beet, and this renders the matter of subduing it comparatively easy. Since the teleutospores do not make their appearance until autumn, and as the carrying the fungus over winter is believed to depend upon the teleutospores the thrifty cultivator will watch for the earlier stages of the

* Sorauer, Pflanzenkrankheiten.
† Frank, Die Krankheiten der Pflanzen.

fungus and carefully collect all leaves showing any sign of infection and burn or otherwise destroy them.

(*d*) TREATMENT.

We are not aware that any direct mode of treatment has been successful in the case of fungi of the family *Uredineæ* to which the Beet rust fungus belongs. If the annual infection is dependent upon the teleutospores we should seek to prevent, as far as possible, their formation. The only spores which are produced entirely independent of the host are the sporidia, which are the product of the germination of the teleutospores. These sporidia are very delicate and exceedingly minute bodies, and if means can be devised for preventing their coming upon the young beet plants, or, should this not be possible, a way discovered to prevent their germinating and entering the leaf tissues by the application of some fungicide (dilute solution of chloride of iron), the disease may be wholly, or in part prevented.

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5.—Leaf Rust of the Cherry, Peach, Plum, etc.

Puccinia pruni-spinosæ, Pers.*

(Plate III.)

(*a*) GENERAL OBSERVATIONS, DISTRIBUTION, ETC.

The Leaf Rust here described is wide-spread in this country, having been observed in nine States, including Massachusetts, Florida, Louisiana, Texas, and California, a fact which would indicate a very general distribution. It is also known in Germany, France, and Great Britain. In the first-named country it is popularly called the "rust of the stone-fruit trees."†

With us it is most generally found upon the plum, but occurs also on the cherry, apricot, and peach. It has been described as the "plum tree brand."

The fungus producing the rust has been described under several different names; that used here is the one adopted by Winter. Some confusion has probably arisen from the fact that the uredo stage alone occurs upon the peach and from the resemblance of the uredospores to the teleutospores of *Uromyces*.

The uredospores may or may not be present on the plum,‡ but on the specimens examined a few have been found in all cases mingled

*The more important synonyms are *Puccinia prunorum*, Lk., *Uredo prunastri*, D. C., and *Uromyces prunorum*, Fckl.

† Frank, Die Krankheiten der Pflanzen, p. 486.

‡ Peck, XXV, p. 116.

with the teleutospores. Some leaves gathered in Aiken, S. C., in April had nothing but uredospores but they seem to persist until winter, as specimens collected December 26, in Texas, still showed a large number. The climate may, of course, have something to do with their presence.

(*b*) EXTERNAL CHARACTERS.

The appearance of the diseased leaves differs according to the species attacked. On the Peach small, round, powdery spots of a yellowish-brown color make their appearance upon the lower surface of the leaf, and directly opposite these, upon the upper surface, the tissue turns reddish-yellow. So far as known this appearance does not change throughout the year, except that as the spots grow older they may turn brown upon the upper side. The Plum may have similar spots early in the season, but later these are mingled with dark, purplish-brown, powdery spots below, and above they may be yellow or dark brown. The spots are irregularly scattered over the leaves and sometimes confluent.

(*c*) MICROSCOPICAL CHARACTERS.

The fungus of this disease, like that of the Beet Rust, belongs to the family *Uredineæ*, but in this case the æcidio-stage of the parasite is not known. The known spores, which have strongly marked specific characters, are formed upon a stroma beneath the epidermis, which they finally rupture, and they, together with the stroma, project slightly above the surface. The spores are interspersed with paraphyses (Fig. 8), having expanded globular tips with walls thickened at the apex, giving them the appearance of immature uredospores. The uredospores (Figs. 6 and 7) are light yellow in color and of a very irregular form, varying from club-shaped to oblong, but are most often obovate; the walls are thin except at the apex, where they are greatly thickened; the surface is echinulate, but the spines diminish in size towards the apex, and are scarcely visible upon the thick part of the wall; the endospore is pierced by two germ pores (Fig. 7, *c c*) situated just below the thickened portion of the wall.

The teleutospores (Fig. 9) are dark-brown, two-celled bodies, so strongly constricted in the middle that the cells are usually about the same size, but the upper one is sometimes larger, and the lower may be colorless in some cases. The wall is of unform thickness, and is covered with short, thick spines, set very close together.

Both teleuto and uredospores have comparatively short pedicels. The former have never yet been found upon the Peach, and it is probable that they do not occur upon it at all, since specimens gathered in Texas as late as December 26 failed to show any.

In regard to the disastrous effect of this fungus on the Peach a Texan correspondent writes, October 18, that "the fungus caused nearly all the leaves to fall within the last four week, even the second growth."

The wild as well as the cultivated plums are attacked, a fact that will render infection of cultivated trees certain when there are diseased native ones in the vicinity.

(*d*) TREATMENT.

Little can be said in way of treatment, and all experiments in this line must be wholly empirical. As stated above, we do not know

the first or æcidio-stage of the fungus, and it is not certain that this stage is necessary for its continued propagation. The parasite is endophytic, or grows within the tissues of the leaves of the host plants, and by the time it has become visible on them by its production of spores, the body of the fungus has already attained considerable growth and is beyond the reach of fungicides. We can only hope to keep the disease off the trees by preventive applications, and in localities where some treatment seems to be imperative we suggest spraying the foliage with some of the sulphate of copper solutions, eau celeste for example, as being most likely to be protective. Very dilute solutions of chloride of iron may also protect the trees from the attacks of this parasite.

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6.—COTTON-LEAF BLIGHT.

Cercospora gossypina, Cke.

(Plate IV.)

(*a*) GENERAL OBSERVATIONS, DISTRIBUTION, ETC.

The disease here named Cotton-leaf Blight is quite distinct from the dreaded "Cotton Rust" that so often has blasted the hopes of the planters, and, in comparison, is of little consequence. Anything, however, which may affect a crop of such vast importance, even though slightly, deserves consideration.

A number of fungi are known to infest the living cotton plant, but, so far as we have observed, the one most conspicuous from the effects produced is *Cercospora gossypina*, Cke. This fungus was first described by Professor Cooke in Grevillea, Vol. XII (September, 1883), page 31, from specimens collected in South Carolina and distributed by Ravenel.* Excepting that it has been occasionally confused with the true Cotton Rust, we do not know that it has received any attention from popular writers. Ravenel knew of its occurrence in South Carolina, Georgia, and Florida. The writer has observed it in North Carolina and Texas, so that the disease is likely to occur throughout the cotton-growing States.

In a field the disease first appears at points where the soil is damp or poorly drained, and the lowermost leaves are generally the first to be attacked. Frequent showers or heavy rains are favorable to the spread of the malady, and at the time of picking, one will often find all the leaves on many plants more or less affected.

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* Rav. Amer. Fungi, No. 583.

The fungus begins its attacks as soon as the first leaves are fairly formed, and from that time until the close of the season it continues its depredations. Our observations have not been sufficiently numerous or complete enough to enable us to make any definite statements as to the actual injury occasioned by the blight. The vitality and assimilating powers of the diseased leaves are more or less affected, according to the virulence of the attack, and in severe cases a seriously diminished crop must necessarily be the result.

(*b*) EXTERNAL CHARACTERS.

If the lower leaves are carefully examined about the time the plants are beginning to bloom, one will see, here and there, some of them marked with reddish-brown spots, irregular in outline, and variously scattered over the leaf surface. The single spots vary from 1^{mm} to 4^{mm} in diameter, but often several of these run together, producing discolored patches of considerable size. The spots are visible on both surfaces of the leaves, showing that the tissues through their entire thickness are affected. In a short time the tissues within the spots die and turn brown, leaving a dark red, well-marked border between the dead and the surrounding healthy tissues. The dead centers of the spots become brittle and are easily broken out, so that the leaves are often seen full of holes, or more or less ragged and torn about their margins. Leaves badly affected soon lose their lively green color, turning to a pale, sickly yellow, and finally wither and fall from the stalks.

(*c*) BOTANICAL CHARACTERS OF THE FUNGUS.

The *Cercospora gossypina* which causes the blight is a fungus botanically related to the fungus of the Strawberry-leaf Blight, but while we are now acquainted with the several stages in the development of the latter (see p. 339), we know only one stage in the former—the *Cercospora* stage—corresponding to the *Ramularia* stage in *Sphærella fragariæ*.

It is the vegetative portion or plant body of the fungus, growing within the tissues of the leaves which occasions the destruction of the cells in the latter, producing the external changes noted above. After a while there issues from the mycelial threads within, usually coming out through the stomata, short, irregular, dark-colored branches, upon whose tips the slender, tapering, colorless spores are borne. These branches generally issue in tufts or fascicles of three or four or more, and the number of spores borne on each varies from one to several. The length of the branches as well as that of the spores varies greatly, and the number of septa or cross-walls in the latter is also variable.*

As already intimated, the more advanced stages in the life history of this *Cercospora* are unknown, but it doubtless produces spermogonial and ascosporous forms on the affected leaves after they have fallen to the ground.

What applications or treatments may serve to check or prevent the Cotton blight remain to be determined by experiment. It may

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*The characters of the species as given by Cooke are as follows: *Epiphylla. Maculis effusis, indeterminatis, fuscis. Hyphis subfasciculatis, elongatis, flexuosis, fuscis* ($.12^{mm}$–$.15^{mm}$). *Sporis elongatis, superne attenuatis, flexuosis,* 5–7 *septatis, hyalinis* ($.07^{mm}$–$.1^{mm} \times .003^{mm}$).

not be practical, or, rather, it may not pay to attempt any treatment unless the disease should become more injurious than it appears to be at present.

7.—ANTHRACNOSE* OF THE RASPBERRY AND BLACKBERRY.

Glœosporium venetum, Speg.

(Plate V.)

(a) HISTORY OF THE FUNGUS.

In the *Agricultural Review* for November, 1882, Prof. T. J. Burrill, of Champaign, Ill., published an account of this fungus under the name of the "Raspberry Cane Rust." This is, so far as we are aware, the only publication relative to the subject. Professor Burrill did not name the fungus but merely referred to it as the "Raspberry Cane Rust," the popular name by which it is generally known, stating, however, that the parasite probably belonged to the same group as the fungus that caused the disease of the grapes known as Anthracnose. During the past two years numerous complaints of the serious injury caused by this fungus have been received by the Section from Illinois, New Jersey, Texas, Wisconsin, and Missouri, indicating that the disease is wide-spread and destructive.

The first time the disease was observed in Missouri was in May, 1887, in the horticultural grounds of the Missouri Agricultural College, and later in the season in various parts of the State. On June 7, a raspberry plantation of 250 acres, located in the southern part of the State, was visited, and it was found that nearly all of the Black-caps were suffering from the attacks of the parasite. Other plantations in the southwestern part of the State were examined, and in all cases the Black-cap raspberries were attacked. The owners, in many instances, were ignorant of the cause of the trouble; some thought that the injury was due to insects, while others attributed it to "sun scald." From information received from the fruit-growing region of Illinois, it is evident that the parasite caused considerable injury in that State. In a letter dated June 20, 1887, Mr. F. S. Earle says "that the 'Raspberry Cane Rust' is seriously injuring Black-cap raspberries and the thornless varieties of blackberries in southern Illinois."

An instance is given by Professor Burrill* of a blackberry plantation that yielded a profit of $400 a year which was so reduced in one year by the disease that it scarcely paid expenses the year following. From a careful examination of the raspberry plantations in southern Missouri the past season, the apparent injury to Black-caps is estimated to be from 10 to 12 per cent. of the entire crop. In some sections the injury is much greater than in others; but we believe this is a fair estimate of the general loss.

In November, 1887, Messrs. Ellis and Everhart described the fungus under consideration and, believing it to be a new species, named it *Glœosporium necator*.† These authors state that the fungus was re-

* This name is proposed for the disease caused by this *Glœosporium* in uniformity with anthracnose of the vine caused by another species of the same genus.

*Agricultural Review.

† Journal of Mycology, III, 129. *Glœosporium necator*, E. and E. On living canes of black and red raspberry. Sent from Evanston, Ill., by Charles Wheeler, August, 1881, and from Cobden, Ill., by F. S. Earle, June, 1884; also received from Columbia, Mo., June, 1887, from B. T. Galloway. **Spots caulicolous pale, with a slightly raised**

ceived by them from Evanston, Ill., in August, 1881, and from Cobden in June, 1884, and again from Columbia, Mo., in June, 1887. They add that *Glœosporium venetum*, Sacc., a European species found on *Rubus*, has spores of about the same size as their *G. necator*, but the former occurs on the leaves of the host, while the American fungus is found on the canes.

We have no specimens for comparison, but the description given by M. Spegazzini of *Glœosporium venetum*, published in 1877,* applies perfectly to the American fungus described by Ellis and Everhart in everything excepting that it is said to occur on the leaves.

In the description of *G. necator* reference is only made to its occurrence on the canes; the fact of its being very common on the leaves was apparently unknown to the authors of the species. Recent observations have led to the discovery that no part of the plant above ground is free from the attacks of the parasite. It is occasionally seen attacking the fruit, and the petioles and veins of the leaves are often greatly disfigured by it.

(*b*) EXTERNAL CHARACTERS OF THE DISEASE (Fig. 1).

That the disease is directly due to the action of the fungus, which is a true parasite, there can be no question.

On the canes.—The fungus attacks both fruiting and non-fruiting canes or suckers. On the latter it usually appears first near the base, producing small purple spots that are variously scattered around the cane. The spots first formed rapidly increase in size, and as the fungus develops the center of each becomes grayish-white in color. Surrounding each spot is a slightly-raised, dark purple border, separating the healthy from the diseased tissues. The course of development is from the lower portion of the canes upwards, so that at any time during the growing season the tip of the cane shows only the minute purple spots or early manifestations of the disease, while towards its base are found the older and larger spots. In an advanced stage of the disease the spots coalesce or run together, and appear as irregular blotches, which are frequently an inch and a half long, and sometimes completely encircle the cane. The direct damage to the tissues rarely extends to the pith; the greatest injury is confined to the cambium layer, or the portion through which the sap is conveyed in the process of growth. Thus, nearly the same effect is produced on the cane by the action of the fungus as would result to a living tree if girdled by the knife or ax. The living tissues of the

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dark border, two to three millimeters in diameter, orbicular or elliptical; spores oblong-elliptical, 5–7μ by 3μ, oozing out in an amber-colored mass through a single opening in the center of each spot. Reported as being very injurious. *G. venetum*, Sacc., has spores of about the same size but is a folicolous species. The Illinois specimens were reported as *Phyllosticta necator*, but the fungus is evidently a *Glœosporium*.

* *G. Venetum* Spez. Spots marginate, without definite shape, large or small, and elevated in the center, honey or ocher yellow, surrounded by a dark purple border. Acervuli minute, prominent, gregarious, or solitary, dark; condidia oblong-elliptical 7–8 by 2½; granulose or nucleated, hyaline. In languishing leaves of *Rubus Chamœneorus.* Belluno and Coneg. liano, Italy. Saccardo, Sylloge Fungorum, Vol.—, p. 706.

There appears to be no good reason why a new name should be given our American form. The specific character of many of the imperfect fungi, of which this is one, are too often based upon characters that rarely remained fixed, and it is useless to multiply names which only lead to confusion. Therefore, Spegazzini's name *Glœosporium venetum*, being the earlier one published, is here adopted.

cane are prevented from properly performing their work, and as a result the canes become sickly; the leaves do not attain more than half their normal size, and if fruit is formed at all it never reaches its full development, but ripens prematurely or simply dries up and is worthless. If the young canes are not killed the first year the continued action of the fungus on the leaves and branches prevents the formation of fruit the succeeding year.

On the petioles and veins of the leaves.—Soon after the appearance of the fungus on the canes the petioles of the oldest leaves are also attacked. There appears near the base of the petiole the purplish spots which always mark the first development of the fungus. These are similar in appearance to those on the canes already described. Gradually the disease spreads along the petiole toward the leaf, and soon the frame-work of the latter shows the whitish, blister-like spots.

The parasite usually confines its attacks to one side of the petioles and veins, which results in an unequal development, the leaves become distorted, and their edges rolled inwards towards the midrib. Frequently the pedicels of the fruit are attacked, and this is usually followed by the complete drying up of all the berries.

On the parenchyma of the leaves.—The fungus produces spots on the leaves similar to those on the canes, excepting that they are much smaller (scarcely exceeding 1^{mm} in diameter) and more closely approximated, but rarely coalescing. The injury extends through the entire thickness of the leaf, and frequently the diseased tissue separates from the surrounding healthy part and the leaf becomes riddled with holes.

(c) BOTANICAL CHARACTERS OF THE FUNGUS.

About 60 species of the genus (*Glœosporium*) to which the fungus of Anthracnose of the raspberry and blackberry belongs are known to occur in the United States. They are all true parasites, but very little is known respecting their development. The species attacking the raspberry and blackberry consists of three parts, namely, (1) the mycelium or body of the fungus, composed of very slender, colorless threads; (2) slender stalks, called basidia, and (3) reproductive bodies, called spores, that are borne upon the tips of the basidia.

The mycelium creeps between the cells of the host and obtains its nourishment at the expense of the latter. As a first result there is simply a slight discoloration of the cell contents; later the cells lose their shape, and very soon they collapse entirely, leaving nothing but a mass of dead and dry tissue. Just as far as the fungus threads extend the tissues of the host are destroyed (Fig. 2). As already stated, the injury rarely reaches to the pith; for the most part it is confined to the bark and cambium layer. Near the center of the diseased spot the ends of many of the creeping threads unite and form a dense tuft, which, as seen under the microscope, resembles a mass of short, slender, club-shaped bodies ranged side by side. These bodies are the basidia; they are formed beneath the cuticle, which they soon rupture, and appear on the surface in the form of a minute globule, being covered with a clear gelatinous substance.

Upon the tips of the basidia the spores are borne (Fig. 2, *a*); these are colorless, oval or oblong, and very minute one-celled bodies. Each basidium develops but a single spore, and the entire mass of spores and basidia are held together in the gelatinous substance, which, however, readily dissolves in water.

If the diseased spots are examined after a week or ten days of dry weather an abundance of the minute globules above referred to will be seen. If a rain follows, the substance which cements the spores together is quickly dissolved and the latter are set free. A microscopic examination of the drops of water which collect on the canes and leaves after a rain will show numerous spores floating about, and many will be seen to have germinated by sending out delicate colorless filaments or germ tubes.

Spores (Fig. 3) sown in a drop of water germinate at the expiration of about twenty-four hours, so that if the water which sets the spores free evaporates shortly after the gummy substance is dissolved, the former are in such condition that the slightest breath of air is sufficient to carry them from place to place. If they fall upon healthy leaves or canes, and the proper conditions of moisture and heat are present, they will germinate, and it is very probable that the slender filaments produced will penetrate the cuticle of the plant and ultimately produce new diseased spots and give rise to the same fungus development from which they were derived.

Early in June of the present year (1887) numerous sowings of the spores were made in various solutions prepared by macerating the green and ripe fruit in water, and juices made in a similar manner from the leaves and young canes were also used. It was found that spores sown in pure water germinated much more readily than any sown in the solutions. It was also discovered that if the spores which had germinated in pure water were removed to the prepared solutions, the filaments therefrom grew with greater vigor than when left in pure water. From these experiments it would seem reasonable to believe that pure water is required, if not absolutely necessary, for the germinations of the spores, and that the germinating filaments, after they have entered the tissue, find in the juices of the plant all that is necessary for their future development. Another fact which would further warrant us in this belief is that the disease rarely spreads during dry weather. It spreads rapidly, however, during damp weather and at times when moisture collects in drops on the canes. Although no new spots are formed during a dry season the old spots continue to enlarge, and frequently the leaves wilt, owing, no doubt, to the fact that the injured cane can not supply the necessary amount of moisture. It is not known how long the mycelium is capable of retaining its vitality; nor do we know of any other mode of propagation excepting by the spores above described. Possibly the fungus lives in the old canes through the winter, and is capable of developing a new series of spores the following spring. This may or may not be the case. One fact, however, in this connection is worthy of note, and that is, that spores taken from old spots after the canes have been kept for several months in an herbarium will germinate.

The fungus under discussion is only known in its active or injurious form; other stages may occur, but they have never been satisfactorily made out. A *Phoma* which develops an immense number of minute, oval, colorless spores is frequently found on the old spots made by the *Glœosporium*. In this *Phoma* the spores are produced within minute dark-colored sacs, called pycnidia, which appear to the naked eye as minute black specks. Another fungus, very similar to the above, but which should be referred to the genus *Phyllosticta*, has been found associated with the *Glœosporium*, but whether either

of the above are in any way genetically related to the latter has never been demonstrated.

(*d*) TREATMENT.

As a means of preventing Anthracnose of the raspberry we suggest that the plants be trained and pruned in such manner that plenty of air and sunlight will at all times be permitted to come in contact with the canes. By far the most vigorous plantations that have come under our observation were those in which the rows were 6 feet apart and the plants were 5 feet apart in the row. Cultivation was made both ways and by careful pruning the plants had been made to assume a close, compact form.

In no case should the canes that have been killed by the fungus be permitted to remain in the field, as all the evidence at hand indicates that the disease first appears where such canes have been left standing. We have in mind a small raspberry plantation in which the disease was first noticed near the center of the field among the plants of the Souhegan variety. The plants in question had been neglected for two or three years, and as a result the canes were long and straggling and many of them were dead. As a further detriment to their growth the suckers had grown up so thickly about the lower part of the plants that they were completely choked. On these plants the disease first appeared, but soon spread to adjoining rows which had received better treatment. Upon an examination of the canes where the disease was first observed the old scars made by the fungus the previous year were found, showing that the disease had been present for several years but had escaped detection.

Sulphate of iron has been used with success in combating the Anthracnose of the grape, and it is reasonable to suppose that, if used properly, it will prove an effective remedy against the very similar disease of the blackberry and raspberry. Prepare a solution by dissolving 2 pounds sulphate of iron in 5 gallons of water, and, by any convenient method, apply to the shoots before the buds have started in the spring. Later, if there be any signs of the disease, the use of the Bordeaux mixture is recommended.

8.—ANTHRACNOSE OF THE BEAN.

Glœosporium lindemuthianum.

(Plate VI.)

(*a*) GENERAL OBSERVATIONS.

Wax or butter beans, those having yellow pods, are subject to the attacks of a fungus parasite producing a disease which may be named Anthracnose of the bean. It is sometimes called "rust," but that term should be restricted to a disease resulting from another cause.

The disease has been known to gardeners a long time, but its botanical nature has not been studied until quite lately. It was first named by Saccardo and Magnus, and has since been studied (1883) by Frank.*

*An account of this disease, with a figure illustrating its character, by Prof. William Trelease, was published in the *Cultivator and Country Gentleman*, October, 1885.

It occurs in Germany, France, Italy, England, and the United States. In the latter country it seems to be very generally distributed, as specimens have been sent to the Department from Maine, Massachusetts, Wisconsin, Pennsylvania, Louisiana, and the District of Columbia. An allied species, *G. leguminis*, is also found in California, upon a different host, however.

It is the pods and the beans they contain that are chiefly affected, the other parts of the plants being rarely if ever attacked. Frank attempted to infect the leaves and stems, but with no result. He also tried to infect different plants, but failed in this also. In this country, however, the disease attacks water-melon rinds as well as beans.

(*b*) EXTERNAL CHARACTERS.

The disease makes its appearance as a small, reddish-brown spot which grows rapidly, soon becoming black in the center. With the exception of a narrow line on its circumference this black center afterwards turns to a dirty gray or light brown.

The spots are usually round, from 2^{mm} to 6^{mm} in diameter, the largest rarely exceeding a centimeter.

They are composed of a reddish-brown band on the outside, followed within (in most cases) by a narrow black band, and have a brownish or dirty white center, over which is a mass of light-colored powder. The spots may grow until they extend entirely across the pod, and several sometimes coalesce, forming large brown patches that nearly cover its surface (Fig. 1). From the first, these spots are sunken below the surface of the healthy tissue, and as the disease progresses they sink deeper and the pod becomes more and more shrunken, while the bean within may also become diseased and shriveled until it has but a small fraction of its normal size (Fig. 3, *b*).

(*c*) CONDITIONS FAVORING THE DISEASE.

The young fruit is most subject to attack, and if the parasite gains a footing in the partly-grown pods, it is, of course, very disastrous, as the growth of the bean is checked, even when the latter is not diseased. It will readily be seen that the parasite, if at all prevalent, is a very injurious one to the crop; and as a matter of fact this is often the case where the conditions are favorable to the fungus. These conditions are simply dampness of soil and atmosphere, which, although favorable to nearly all parasitic fungi, seem to be more necessary to the development of this particular disease than it does in the majority of cases, and an airy, dry situation for the plants is the best means of preventing an attack.

(*d*) BOTANICAL CHARACTERS.

As found upon the bean pod the mature fungus consists of a mycelium, which penetrates the tissue of the pod and bean, sending basidia to the surface, which in turn bear numerous spores.

In general the mycelium is colored, but portions may be uncolored, even where the remainder is quite dark. It is branching, septate, of variable diameter, and contains granular protoplasm and large oil drops (Fig. 4, *b*).

The basidia (Fig. 4, *c*) are colorless and straight, with bluntly-rounded tips, and are borne in clusters.

The spores (Fig. 4, *e*, and Fig. 5) are about twice as long as broad, nearly cylindrical, rounded at each end, contents granular and without nuclei. They sometimes project from the clusters of basidia in compact masses, held together by some substance which dissolves at once upon coming in contact with water.

Mingled with and surrounding the clusters of basidia are a few large dark-brown hyphæ (Fig. 4, *d*), closely resembling the filaments of *Vermicularia*. They are much larger and longer than the basidia of the *Glœosporium*, are septate, and sometimes have a bulbous swelling at the level of the tops of the basidia; below this point they are colorless. Sometimes the whole hypha is uncolored, but in this case it is usually smaller, indicating that it is not mature. They are few in number as compared with the basidia, a dozen being a large number for one cluster or pustule. These hyphæ are not mentioned in any published account, but they were constant in the specimens examined, although very scarce in some cases. The specimens were from the States previously mentioned and from Germany, and were named by Ellis, Farlow, and Trelease. They were also present in the same fungus on water-melon rind.

Life history.—The spores falling upon the surface of the bean pod, send out a protuberance or germ tube on one side which presses close against the epidermis, and becomes transformed into a round, flattened body with a thick violet membrane. From this there soon protrudes a colorless hypha that bores through the outer wall of the epidermal cells and grows within them into a convoluted mycelium which fills their cavities* and extends rapidly downwards and laterally.

In its healthy state the bean pod is composed of two well-marked layers of tissue with a line between. The outer (exocarp, Fig. 2, *b*) is the firmer and more compact, and is generally of about the same thickness throughout the pod. The inner (endocarp, Fig. 2, *c*) is composed of larger and thinner walled cells, and is not continuous. If the beans are fully developed it is quite absent along their length, and very thin even in the intervals between them; but if the beans are not well-grown it is very thick, and in the intervals may fill all the space within the outer layer. It is accordingly thick in pods where the fungus has checked the growth of the bean.

After leaving the epidermal cells the mycelium penetrates the walls of the cells beneath it, their contents and walls almost immediately become discolored, and in the exocarp the cells collapse, forming an almost solid mass of cell walls and mycelium (Fig. 2, *a*). In the endocarp the cells do not collapse at once, but the mycelium grows in them luxuriantly, almost filling their cavities; from here it penetrates to the bean itself, and may even form spores and basidia between the testa and embryo.

The exocarp shrinks into a mere line and sometimes separates from the endocarp like the skin of a blister. Usually, however, the two layers remain connected, and the whole spot sinks in (Figs. 2 and 3).

The mycelium that is in the epidermal cells in the center of the spot soon forms basidia which rupture the epidermis at points, forming pustules (Fig. 4); these pustules are so numerous in the older spots that they coalesce and are lost sight of, so that the surface is nearly or quite covered with a mass of basidia. The pustules are just visible to the naked eye, and sometimes have a dark-brown color,

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*Sorauer, Pflanzenkrankheiten.

owing to the brown hyphæ among the spores. It is from them that the spore masses already spoken of project. They occur only over the light center of the spot, the black line forming their limit; in fact, the light color is probably caused by the spores and ruptured epidermis.

The presence of the large dark-colored hyphæ raises a question of classification. These hyphæ are not mentioned in any description of *Glœosporium*, and, so far as is known, are not present in any other species of that genus, but are, on the contrary, characteristic of the genera *Vermicularia* and *Colletotrichium*. The appearance and structure of the bean fungus accords perfectly with the description of *Colletotrichium*, even to the location of the brown hyphæ (setæ) about the circumference of the pustule, and if the setæ are an organic part of the bean fungus it seems probable that the name must be changed from *Glœosporium* to *Colletotrichium*.*

(*e*) TREATMENT.

So far as possible plant in a dry and airy situation in light soil. Sulphur has been used and is reported to check the disease somewhat, but is not a sure protection. Under some circumstances applications may be made of solutions of sulphate of iron or copper, but the use of these compounds on this fruit can not be generally recommended owing to their poisonous character. Experiments might be made with liver of sulphur, 1 ounce to 5 gallons of water.. The action of this fungicide is immediate, and it may be freely used without danger to health.

9.—LEAF-SPOT DISEASE OF CATALPA.

(Plate VII.)

(*a*) GENERAL OBSERVATIONS.

The foliage of a number of our ornamental shade trees is sometimes seriously disfigured or caused to fall prematurely by the attacks of parasitic fungi. A notable example of this is the case of the catalpa (*C. bignonioides*), some trees of which, growing on grounds near the Department buildings, have had their leaves more or less injured from this cause for several seasons past. The work of the fungus is manifest by round, brown spots upon the leaves which appear early in June, and in some few instances the ravages of the parasite have been so severe as to nearly defoliate certain trees by the end of July or early in August.

The geographical limits of the disease are not known, but it is evidently quite extended, as samples of the affected leaves have been observed in widely separated localities.

(*b*) EXTERNAL CHARACTERS.

So far as we know the attacks of the the parasite are confined to the leaves, where it produces the brown spots mentioned above. These spots are round, varying from 3^{mm} to 6^{mm} in diameter, and

*Dr. O. Penzig, in Ann. d. Agria., 1887 (Studi Botanici Sugli Agrumi e Sulle Piante Affini), Pl. XXXVIII, Figs. 3 and 4, p. 384, has figured and described *Colletotrichium glœosporioides*, and so far as can be judged from the illustrations, the fungus has every generic characteristic of that upon the Bean. In his Funghi Agrumicoli, 1882, p. 66, Fig. 90, Penzig described the same fungus as *Vermicularia glœosporioides*.

they occur indifferently on any part of the leaf, often running together, forming large brown patches, and in severe cases they occupy the greater part of its surface, seriously interfering with the process of assimilation. They are caused by the growth of the parasite within the tissues, whose limited development causes the sharply-defined, rounded outline of the spots. The tissues are destroyed through the entire thickness of the leaf, and this portion often breaks away completely from the surrounding healthy parts, leaving the leaf full of round holes. Fungi producing this effect are sometimes named "shot-hole fungi." In advanced stages of the disease the leaves become wrinkled and deformed; finally, losing all vitality, fall to the ground.

(c) MICROSCOPICAL CHARACTERS.

A section through one of the spots where it joins the healthy tissue shows a well-defined boundary in the tissues by a peculiar transformation of the cells. In the yellowish-green border by which most of the spots are surrounded the different leaf tissues become a homogeneous mass of parenchyma; within this the tissues are so shrunken and altered that the cells have lost all definiteness of form and contents, forming a brown and disorganized mass (Fig. 1, *b*).

This disease appeared to be sufficiently important to demand further investigation, and some time was occupied in this work.

Several different fungi were found on the dead spots, those worthy of note being *Macrosporium catalpæ* and *Phyllosticta catalpæ*. Both these species are described by mycologists as forming spots; both were observed on the same spot, and the mycelium of both was found penetrating the tissues.

The *Macrosporium* is the more abundant of the two, being generally constant on both sides of the leaf, excepting on the very young spots. Its growth sometimes extends beyond the limits of the latter to the green tissues immediately surrounding them. The conidiophores, or spore-bearing stalks of this fungus, are reddish-brown; they occur singly or in groups, and on the under side of the leaf they were frequently seen emerging from the breathing pores or stomata (Fig. 2). The spores (Fig, 2, *b*, and 3) are compound or made up of a number of cells, each cell or division being capable of ready germination (Fig. 3). The mycelium produced by germination is comparatively large, colorless, frequently divided by septa, and its growth is readily carried on in a variety of media.

The sowing of fresh spores on healthy leaf surfaces, an experiment frequently tried, led to no positive results.

The species of *Macrosporium* are so frequent on dead vegetable substances and so rarely, if ever, found alone on living tissues that they are generally believed purely saprophytic in their habits and incapable of producing direct injury to living plants. If this be universally true, then we must look to the other fungus mentioned as the cause of the leaf-spot disease under discussion.

The *Phyllosticta*, many species of which are known to produce leaf-spot diseases in other plants, found on the spots on the Catalpa leaves is doubtless the cause of them. Its mycelium is very delicate, being much finer than that of the *Macrosporium*, so that it is very difficult to see it in diseased substance of the spots, even by the most careful manipulation. The spores of this fungus (Fig. 5) are formed within minute black conceptacles or pycnidia (Fig. 4), that are developed just beneath the cuticle of the leaf which their growth

finally ruptures. These conceptacles are visible to the naked eye, appearing as very minute black points on the surface of the spots. They are not abundant, and often there are many spots, called sterile, entirely without them. The spores are difficult of artificial germination, and no results were attained by sowing them upon healthy leaves.

Possibly there is some genetic connection between the *Macrosporium* and the *Phyllosticta*. This has been suggested as a probability, but the studies we were able to make afforded us no opportunity to form even an opinion on this question.

Where a few trees of catalpa are grown especially for shade or ornament it may be possible to preserve their foliage from this disease by the application (preventive) of some fungicide, but no experiments have yet been made with this end in view.

10.—Black-spot on Rose leaves.

Actinonema rosæ.

(Plates VIII and IX.)

(*a*) GENERAL OBSERVATIONS.

There are several parasitic fungi that produce black spots upon the leaves of our cultivated roses; but the most common and injurious, and the one to which we generally refer in speaking of the "leaf spot," is that known to mycologists as *Actinonema rosæ*. It was named *Asteroma rosæ* by Libert as early as 1826, and afterwards transferred to the genus *Actinonema* by Fries. It is also called *Asteroma radiosum*. The nature of the disease has been studied and described by Frank and Eriksson, and Sorauer describes it in detail in the second edition of his work on "Diseases of Plants."

The disease is very wide-spread, occurring in nearly all the countries of Europe as well as in the United States. Here it is quite universal, although there are local areas apparently free from it.

(*b*) EXTERNAL CHARACTERS.

Late in the spring, or early in the summer, the disease makes its appearance in the form of round or irregularly-shaped black spots upon the upper surface of the living leaves. Generally only the full-grown leaves are attacked, and those within three or four inches of the branches seem to be healthy.

The spots are small at first, but as the disease progresses they increase in size, and may become half an inch in diameter. Often a number of them coalesce, and in severe attacks the leaf is nearly covered with large dark patches.

From the beginning the spots are fringed at the edges, and although the form is frequently irregular at first, they usually become distinctly circular later, especially on the smooth-leaved varieties. In the latter part of the season the spots grow light colored and dry in the center, showing that that part of the leaf is entirely dead, and by this time, if not before, the discoloration penetrates through the leaf and appears on its under side.

The moss roses and those with thick rough leaves, seem to suffer more than other kinds, but there are few, if any, that are invulner-

able to the parasite. Those which escape early in the season are apt to succumb before fall if the other roses in the vicinity are diseased.

The effect of the disease upon the leaf is soon apparent by its turning yellow in places, and sometimes by a yellow band outside the black spot. When cold weather approaches the leaves that are diseased are the first to turn yellow. During the autumn the yellow color is apt to appear at the apex of the leaflets, whence it spreads downward and is succeeded by brown. A leaf with a green base and brown tip with a yellow band between is very characteristic of this disease. Premature fall of the leaves is another effect of this parasite. Diseased leaves may fall before they turn yellow, and plants attacked by the fungus generally have a partly defoliated appearance.

It is evident that we have here a case in which the effect of the fungus is not confined to the area it actually occupies. Its growth does not extend over all those parts of the leaf which turn yellow, nor can any mycelium be found at the base of the petiole when the leaf falls before its time. It seems that the interference with assimilation which must result over the diseased areas so affects the entire leaf as to destroy its vitality. If the autumn is long and pleasant the plant is apt to exhaust itself by putting out new leaves, which are destroyed by frost before they can be of any service.

The fungus is very hardy and does not depend to any great extent upon climatic conditions for its development, but like other diseases of this kind it proves most troublesome in a moist and warm environment.

Roses kept under cover are better protected from infection, and are consequently more free from the disease. This explains why tea roses and others that are kept in greenhouses over winter are not so badly affected as those in open grounds. The truth is, probably, that the disease has a long period of incubation before it is visible, and before this period is over for roses that have been potted the season is far advanced and they do not have time to get badly diseased before they are potted again.

(c) BOTANICAL CHARACTERS.

The parasite, as it is known on the rose, is probably but one stage in the life history of the fungus. From its analogies it is classed with the sphæriaceous fungi, although so far as recorded no perithecia have been observed in this species. But in other species similar in habit to this one, perithecia-like forms, more accurately known as pycnidia, occur.

Mycelium.—The mycelium is composed of two distinct parts, one situated between the cuticle and epidermis (Plate IX, Fig. 2, *b*), and the other penetrating the leaf tissues. The former is apparently superficial (Plate VIII, Fig. 2), as it shows through the transparent cuticle. It is composed of branched septate hyphæ that radiate from a center and lie side by side in strands of from one to eight (Plate VIII, Figs. 2 and 3). When a hypha branches it may run along parallel to the main thread or may bend off at an acute angle and form an independent strand (Plate VIII, Fig. 3). Other mycelial filaments branch off from the under surface of this superficial layer and penetrate the leaf tissues, first entering the epidermal cells and sometimes nearly filling them with convolutions (Plate IX, Fig. 2). From these it pushes between the palisade cells, and finally appears

in the loose parenchyma (Fig. 3). Below the epidermal cells it is rarely visible, since it is so transparent that it is easily concealed by the cell contents; but when the cells are dead and shrunken it can be seen between them (Fig. 3). It penetrates the tissues very slowly, and reaches the loose parenchyma only in the last stages of the disease. This second portion of the mycelium absorbs nourishment for the entire fungus.

Spores.—The spores are borne upon the superficial layer. Short vertical branches may arise upon any of the strands; these branches force the cuticle apart from the epidermis and soon form colorless two-celled spores upon very short basidia. When the spores are nearly full-grown the pressure upon the cuticle becomes great enough to rupture it irregularly (Plate IX, Fig. 2, *b*), allowing the spores to escape (Plate IX, Fig. 2). The mature spore is deeply constricted at the union of the two cells. The cells are oblong, nearly twice as long as broad, sometimes larger at the ends than in the center, and contain two nuclei. Sometimes the two cells fall apart; and before they become free from their basidia, the lower one frequently has the appearance of a pedicel (Fig. 4).

The effect of the parasite upon the leaf tissues is at first apparent in the shape of a dark yellow mass, evidently composed of the transformed cell contents that collect in the upper part of the epidermal cells. The upper row of palisade cells next become discolored, and the chlorophyll bodies disorganized, and this process slowly extends through the leaf. It is this discoloration of the cell contents that gives the dark color to the spot. In some species of *Actinonema* the mycelium itself is dark colored; but on the rose it has little or no color, and the fringed appearance of the spots is due to the fact that a few discolored cells follow the mycelium where single strands project beyond the others. Just underneath the fruiting spots the mycelium seems to have some color (Fig. 2, *d*), and these spots look blacker than the surrounding surface.

(*d*) TREATMENT.

Owing to the hardy nature of the fungus and to the fact that the mycelium develops within the leaf tissues, the disease is very difficult to deal with. Although the fungus does not live over winter in the woody portions of the plant, the disease, having once entered a garden, is sure to re-appear for successive seasons, for the spores are lodged upon the buds at the bases of the petioles by water trickling down the leaf-stalk, and the shoot springing from these the following season is necessarily tainted. For the same reason cuttings from diseased bushes will spread the fungus. Unless some plan can be adopted by which the spores can be destroyed early in the season, before they have germinated and produced a mycelium within the leaves, a garden once infested by the parasite is beyond recovery, and a new site must be selected in which no roses must be planted that are not perfectly healthy.

It is probable, however, that we may succeed in saving roses once attacked. For this purpose all the leaves should be carefully burned in the fall, and the bushes and ground carefully sprayed with some fungicide before the buds start in the spring. Much may also be done by picking and burning every leaf as soon as it shows the faintest trace of disease.

A solution of copper sulphate may be used for spraying the bushes, but should not be used upon the leaves, as it will be apt to burn the

foliage. After the leaves have started applications of Bordeaux mixture or eau celeste, modified by the addition of carbonate of soda, will be beneficial in preventing the spread of the disease. This treatment should be repeated three or four times during the season, so as to protect succeeding growths of leaves.

11.—Rose rust.

Phragmidium mucronatum, Winter.

(Plates X and IX.)

(a) historical.

The rust of roses is a disease which has been known to botanists and horticulturists for nearly a century. The minute parasitic fungus causing the malady was first described by Schrank,* a European botanist, under the name of *Lycoperdon subcorticium*. Many later botanists have described it under various names.†

For a long time it was retained in the genus *Puccinia*, but Link, in 1825, placed it in the genus *Phragmidium*, where it still remains.‡

This parasite is common in Europe and is widely distributed in this country, attacking both wild and cultivated plants; in severe cases the death of the host is the result. It has recently been observed in California, by Prof. S. M. Tracy, infesting to an injurious degree hybrid perpetual roses; in one instance a Maréchal Niel, growing in a greenhouse, was very badly affected. Tea roses rarely suffer from its ravages; it is the hardy, hybrid perpetuals that suffer most.

(b) external characters (Plate X, Figs. 1 and 2).

Early in summer the disease first makes its appearance on the leaves, leaf petioles, or young stems in the form of variously-shaped lemon-yellow spots, which increase in size as the season advances. On the leaves the spots are scattered irregularly over both surfaces, being lighter in color above and below. These spots mark the points of development of the fungus, and as this development progresses within the tissues the parasite finally breaks through the epidermis on the under surface of the leaves, forming little granular pustules. The larger pustules appear on the principal vines, along which they may extend for a considerable distance. When the nerves are thus attacked the leaves become twisted and misshapen.

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* Hopp's Bot. Taschb., p. 68.

† *Ascophora disciflora*, Tode, Mcke. Fung., page 16. *Aregma mucronatum*, Fries, Obs. Myc., I, page 225. *Phragmidium incrassatum* var. *rosarum*, Wallr., Flor. Germ. Crypt., IV, page 188. *Phragmidium mucronatum*, Lk., Spec. Plant, II, page 84. *Puccinia mucronata* var. *rosæ*, Pers., Syn. Fungi, page 230. *Puccinia rosæ*, D. C., Flor. Franc., vol. 2, page 218. *Uredo rosæ*, Pers., Dispos., page 13. *Uredo miniata*, Pers., Syn., page 216. *Uredo elevata*, Schum., Enum. Plant. Sacll., II, page 229. *Uredo pinguis*, D. C., Flor. Franc., II, page 225.

‡ It appears to us that the name given this fungus by Link, *Phragmidium mucronatum*, is the one which ought to be adopted, it being the earliest name applied to this species in the genus *Phragmidium*. It is certainly straining a point, needlessly multiplying synonyms, and confusing the citations of authors to revive a part of an older name after the fungus has already been published under *Phragmidium* merely for the sake of paying tribute (doubtful in some cases at least) to him who first describes the fungus or one stage in its development.

The spots on the leaf stalks and shoots are usually larger than those on the leaves. They are elongated in the direction of growth (one-half inch sometimes), and are surrounded by the broken edges of the ruptured cuticle. The action of the parasite often incites an excessive cell development in the tissues of the host, in consequence of which the shoots are found more or less bent away from the point of attack (Fig. 1, *a*).

If we examine the rose leaves closely about mid-summer we will find that the orange-yellow spots have been replaced (to all appearances) by spots of a brick-red color, and later in the season another and more marked change occurs; the under surfaces of the diseased leaves then are seen to be more or less thickly sprinkled with minute black, hair-like tufts. Frequently the brick-red stage and the one last mentioned are found together (Fig. 2), and sometimes all three forms may be seen on the same leaf.

(*c*) BOTANICAL CHARACTERS.

A microscopical examination of the early or orange stage of the disease will show us that the pustules are made up of an immense number of globose or angular bodies arranged in compact vertical rows or chains (Plate X, Fig. 3). The formation of these bodies begins at a point some distance beneath the cuticle, and it is by their growth that the latter is finally ruptured. This period of development is known as the æcidio-stage of the parasite, and the angular or rounded bodies referred to are the æcidiospores. These have an average diameter of from 18μ to 22μ ($1\mu = \frac{1}{2500}$ inch), and, like the seeds of higher plants, they serve to spread and propagate the fungus. With these spores, usually surrounding each group or pustule, are peculiar club-shaped growths termed paraphyses (Fig. 3, *a a*).

In the second or uredo-stage the spores are similar in shape and size to the æcidiospores, but they have their outer surface finely roughened and they are grouped differently (Plate X, Figs. 3 and 4).

Surrounding each collection of these spores the same club-shaped bodies observed in the æcidio-stage occur. These are sterile organs of doubtful function, which accompany the spores of many fungi. In the present instance they have obtuse club-shaped tips and are somewhat incurved and form a sort of cup around the spore masses.*

The spores in this second or uredo-stage are borne on short pedicels and otherwise differ from the æcidiospores in having their outer surface roughened (Fig. 4).

The spores in the third or last stage are very markedly different from those preceding. They appear, when magnified, as illustrated in Plate X, Fig. 7. A more highly magnified figure of one of these spores is shown in Plate IX, Fig. 5. They are very dark colored, roughened, cylindrical bodies, about 25μ in diameter and 60μ to 75μ long, divided by septa into from 5 to 11 cells and abruptly terminated by a short, colorless point. The stalks supporting them are comparatively short, colorless, and considerably enlarged or swollen towards the base. The same colorless paraphyses accompany this stage as were seen in the two preceding,

The æcidio and uredospores germinate readily, under favorable conditions, as soon as they reach maturity; but when kept dry for a

* The uredo-stage of this fungus has recived several names by the older mycologists, among them *Uredo miniata*, Pers., and *Colæosporium miniatum*, Lev.

few weeks they lose this power of germination. The last spores formed, however, the teleutospores, as they are called, retain their vitality for a long time and can rarely be germinated by artificial cultures until the spring following the season of their development. In the process of germination the spores of the first and second stages send out slender germ tubes which, if properly placed, penetrate the tissues of the plants attacked. These spores are evidently designed for the immediate and rapid propagation of the fungus during the growing season, while the teleutospores preserve the life of the parasite during the winter and only germinate in the spring, ultimately giving rise to the various forms we have described.

The teleutospores germinate by sending out somewhat thickened tubes (usually one tube issues from each cell) which, after attaining a length several times that of the spore, produce several minute globose bodies on short and slender stalks. These bodies, named sporidia, are easily wafted from place to place by the slightest currents of air, and when they fall upon Rose leaves where there is moisture they send out slender filaments which probably bore their way through the cuticle into the interior of the leaf, and a new fungus growth takes place.

(*d*) TREATMENT.

Understanding the character and manner of development of the Rose rust enables us to suggest several methods of combating it. In the first place the plants should be carefully watched, and at the first appearance of the disease the affected branches should be removed and destroyed. If the disease re-appears upon the new growth it would be best to dig out the plants and destroy them, as it is better to sacrifice a few plants at the beginning than have them breed infection to all others which may be near.

Never wait until the spots show the granular pustules before destroying the affected parts, but remove the shoots upon the first indication of the yellow spots. Where the disease has prevailed it would be well to rake all the old and fallen leaves together in the autumn and burn them, for by this means millions of the teleutospores will be destroyed.

It is probable that some benefit may result from the use of solutions containing sulphate of copper, as this substance is known to prevent the spores of many fungi from germinating, even when present on the parts subject to attack in very small quantities.

In localities where the disease has prevailed in previous years a preventive treatment may be made by applying to the plants in early spring, a solution of sulphate of copper and carbonate of soda, prepared as directed on page 331. This should be applied to the leaves and young branches with an atomizer, thoroughly wetting all the parts, but not drenching them with the fluid. After drying this preparation is strongly adherent, and its presence even in very minute quantities is sufficient to prevent the spores of the fungus from germinating. It is obvious that if the germination of the spores is prevented infection can not take place. A very dilute solution of chloride of iron, which is reported to have proved efficacious in the treatment of the coffee disease (*Hemileia vastatrix*), may also be tried as a preventive.

12.—THE ROSE PHRAGMIDIUM.

Phragmidium speciosum, Fries.

(a) GENERAL OBSERVATIONS.

The Rose *Phragmidium* belongs to the *Urediniæ* or rust-producing fungi, and like the preceeding, to which it is closely related, it is a parasite of the rose, confining its attacks, however, to the stems, rarely, if ever, infesting the leaves, although it is sometimes found upon the leaf stalks. It was first described by Schweinitz, an American botanist, in 1822, under the name *Seiridium marginatum*. Later it was placed in the genus *Phragmidium* by Fries, who named it *Phragmidium speciosum*.

It is quite generally distributed throughout this country, and complaints have been received by this Section of the injury it has occasioned, one correspondent stating that his plants had been infested for four or five years, the stems attacked being invariably killed.

(b) BOTANICAL CHARACTERS.

Doubtless this species produces the same spore forms as does *Phragmidium subcorticium*, but the samples forwarded to us for investigation exhibit only the last stage or mature form. In this condition the fungus appears on the stems as illustrated in Plate IX, Fig. 6, thickly covering them with black, irregular masses, suggesting at first sight the appearance of certain species of bark-lice. A closer inspection of the cushion-like masses reveals their true nature, and a microscopical examination shows that they are really composed of a dense growth of fungus spores supported on long slender stalks. Several of these spores are represented in Fig. 7. They are brown in color, five to seven celled, with a somewhat abruptly-pointed colorless apex, and are particularly attractive objects under the microscope. In size they are about 30μ in diameter by from 70μ to 100μ in length. The supporting stalk is many times the length of the spore, slightly tinted in its upper part, but colorless below, and nearly uniform in diameter throughout.

The body of the fungus (*stroma*), from which arise the spores, does not penetrate into the woody tissue of the stem, but its growth seems to be confined to the inner bark and cambium layer, the life of which it destroys. In severe cases the stems are often completely girded by the parasite, so that the fatal results arising from its attacks are not difficult to understand.

(c) TREATMENT.

The fungus re-appears each year on the same stems, if they survive, indicating that it is perennial in habit, a fact making it all the more difficult to combat, for there seems to be no remedy that will destroy the parasite which will not be equally destructive to the host.

Heroic treatment with the knife, cutting away all the diseased stems and burying them, is all that we can now recommend. A more complete knowledge of the development and life history of the parasite may enable us to successfully combat without resorting to such severe measures.

13.—The powdery mildew of the gooseberry.*

Sphærotheca mors-uvæ, B. and C.

(Plate XI.)

(a) General remarks upon the growth and development of the powdery mildews.

The mildew that has proved so destructive to the gooseberry industry in the United States, is a member of a group of fungi known to botanists as the *Erysipheæ*. The species of this group are mainly parasitic upon higher plants, and several of them rank among the most injurious of fungi to cultivated crops. The family, according to Saccardo,† is divided into nine genera, embracing a hundred species, about half of which are found in this country.

Among the leading species preying upon cultivated plants is *Podosphæra tridactyla*, De By. This is often abundant upon the leaves and twigs of cherry, plum, and young apple trees, and does much damage in some localities. *Phyllactina suffulta*, Sacc., infests many species of forest trees, as the oak, beech, birch, ash, and catalpa. *Uncinula salicis*, Winter, is common upon willow leaves, while *U. circinata*, C and P., does much injury to the maple, especially the seedling plants. Last autumn it was difficult to find a young soft maple that did not have its leaves badly affected with this mildew. *U. spiralis*, B. and C. (*U. Americana*, Howe) is the Powdery mildew of the grape, fully treated in Bulletin No. 2, Botanical Division, pp. 18–28. Other species of the genus *Uncinula* grow upon our Virginia creeper, mulberry, linden, poplar, and elm. The large genus *Microsphæra* is well represented in the United States. The species upon the lilac, *M. alni*, Wint. (*M. Friesii*, Lev.), is perhaps the most common. It infests the birches and buck-thorn in Europe, but does not thrive there upon the lilac. Other species are found upon the honeysuckle, buttonwood, oxalis, elder, dog-wood, oaks, beeches. and other hosts. The genus *Erysiphe* is the largest in number and has a fair share of its members in this country. *E. cichoracearum*, DC., flourishes upon many compositæ, and may prove injurious to cultivated members of this great Sunflower family of plants. The most troublesome species is *E. communis*, Fr. Lev., which infests all parts of the cultivated peas, often doing mnch injury. Grasses are frequently attacked by members of the genus *Erysiphe*, and become coated with a whitish powdery mildew. June grass is a favorite subject for mildew. *Erysiphella* is a genus with a single known species which preys upon the flower clusters of the alder, giving them a mealy appearance.

The members of the whole family are much alike in their vegetative condition, and differ principally in the structure of their sporocarps, or cases for bearing their several spores. These mildews are all filamentous fungi that attack the host only upon its surface and give to the exterior a whitish or powdery appearance. It is on account of this prevailing mealy or flour-like coating that the common name of "Powdery mildew" has been given to the members of this group. The slender filaments of the fungus may become attached to the surface cells of the host by short irregular outgrowths

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*By Dr. Byron D. Halsted.

†Sylloge Fungorum, Vol. I.

(haustoria) which also serve to absorb the nourishment required for the further growth of the mildew.* After the mildew has grown for a time upon the surface of the host—most usually upon the foliage—it begins to send up vertical branches from the net-work of horizontal filaments. These upright threads quickly form small oblong cells by division walls across the filament near the tip (Plate XI, Fig 1). These cells are the summer or asexual spores and are capable of germinating at once when favorable conditions are found. These conidial spores furnish a very rapid method of propagation for the mildew, and on account of their small size and powdery nature they may be carried for long distances by the wind and thus spread the parasite with startling speed.

Up to this point in the life history of the *Erysipheæ* one species is so much like that of the others that, unless something further is known, the form is not classified, or at least only provisionally. *Oïdium* is an old genus which was used to include the conidial forms of the *Erysipheæ*, and to this time this is still true in some measure. For example, *Oïdium Tuckeri* is the conidial form of a mildew which has ravaged the vineyards of Europe, but of which the final state is not known. We have a mildew of the vine which bears its sexual spores, and is classified as *Uncinula spiralis*, B. and C. It may be that this is the species which leads an incomplete existence in the European vineyards, owing to the changed conditions that there obtain. Any student of this group is quite certain to have an undetermined package of specimens that include only conidial forms. The writer has recently collected some branches from a live oak in California, the whole surface of which, dwarfed leaves included, is heavily coated with a powdery mildew, but from a lack of the whole life history the specimens remain among the unclassified.

The genera and species of the *Erysipheæ* are founded upon the sexual spores and the cases (perithecia) which bear them. The formation of these spores takes place usually after the season of most rapid growth of the mildew is closed. Two filaments unite their contents (Fig. 3) and the invigorated protoplasm begins a new form of development, in which a sac is formed consisting of a nearly spherical shell of thick walled cells (Fig. 4). In this hollow sphere are produced the spores borne within one or more sacs. To repeat, the male element of one filament fertilizes the female cell contents, and the latter produce a number of spores which are borne within a sac, and this sac (or sacs) is contained within a thick-walled body, all of which is seen as a small dark speck upon the surface of the mildewed plant. The fungus at this time is usually of a rusty brown color, instead of white and powdery as in its earlier summer condition. These sexual or perithecial spores (ascospores) do not germinate at once, but remain within the protecting covering until spring, and then begin a new series of developments and repeat the mildew of the previous season. The genera of *Erysipheæ* are founded upon the number of spore sacs (asci) within the perithecium and the character of the arms or appendages which are developed upon the spore case. There is a third form of spore which is borne in large numbers within

* In *Erysiphe pannosa* (*Podosphæra pannosa*, Link), the Rose mildew, *e. g.*, very thin tube-form projections appear on that side of the colorless, septate, mycelial threads which rest on the upper surface of the rose leaf, These projections bore through the outer wall of the epidermal cells, and these swell out in the interior into a bladder-shaped body. These bladder-form projections represent the complete haustorium.—SORAUER.

long, pear-shaped sacs (Fig. 2) that often accompany the perithecia, but arise without any sexual action.*

With this brief outline of the development and growth of the "powdery mildews" we may follow understandingly the life history of the gooseberry mildew, *Sphærotheca mors-uvæ*, B. and C.

(b) SEVERITY OF THE DISEASE.

In order that no one may doubt the destructiveness of this mildew in the United States, the following statements are quoted from the leading standard authors upon fruit culture in this country. Mr. Downing, after stating that our gooseberries come from Northern Europe, our native species not having responded rapidly to the improved condition of garden culture, and that the moist, cool climate of England is the most perfectly adapted to the growth of the gooseberry, says:†

> Under our more clear and hot sun, however, the best varieties of the English sorts do not succeed well, suffering from mildews of the fruit and foliage in nearly every locality.

Patrick Barry‡ says:

> The gooseberry suffers seriously from the mildew, owing mainly to the heat of our summers.

J. J. Thomas, § under "Mildew of the gooseberry," writes:

> This is the most serious obstacle to successful culture of the foreign gooseberry in the United States. In the cool and moist climate of England it does not exist; in the extreme northern parts of the Union it is not formidable, but on approaching the Middle States, although the bushes grow vigorously and set abundant crops of young fruit, the latter becomes covered with a thick brown or gray mildew or scurf which destroys their value.

A. S. Fuller ‖ writes of mildew:

> This is the one great enemy of the gooseberry in the United States. It not only attacks the fruit, but often extends over the whole plant, effectually checking its growth. So prevalent has this become that the foreign varieties are almost universally discarded, as there are few localities where they will succeed.

E. P. Roe ¶ says of the gooseberry:

> This native of Northern Europe and the forests of the British Islands has been developed into superb varieties which have been famous so long in England, but which we are able to grow with only partial success. It remembers its birthplace even more strongly than the currant, and the almost invariable mildew of our gardens is the sign of its homesickness.

Similar extracts might be multiplied, but those given clearly indicate the severity of the gooseberry mildew as found in this country. It not only flourishes upon our garden varieties of foreign extraction, but attacks many of our own wild species of the genus *Ribes*. The

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*This "third form of spore, borne in large numbers within pear-shaped sacs" which are attached to the same mycelium as the conidia and perithecia, have been found in a number of species of *Erysipheæ*. From their position and seemingly evident analogy to certain sexual reproductive bodies in allied groups of fungi they have been regarded as the pycnidia, and the spores which they contain the stylospores of the fungus. De Bary has pointed out, however, that these bodies, instead of being reproductive organs of the *Erysiphe*, are in reality the fructification of a fungus which is parasitic upon it.—F. L. S.

† Fruit and Fruit Trees of America, page 499.

‡ Barry's Fruit Garden, page 477.

§ American Fruit Culturist, page 162.

‖ The Small Fruit Culturist, page 227.

¶ Success with Small Fruits, page 226.

leaves and tips of the young canes of *Ribes rotundifolia*, Michx., are usually badly infested in Iowa, and last summer the writer found the half-grown berries of a wild gooseberry in Colorado, *Ribes divaricatum* var. *irriguum*, Gray, so covered with the fungus as to preclude their perfect development.

(c) EXTERNAL APPEARANCE AND ACTION OF THE FUNGUS.

The mildew first makes its appearance upon the young half-grown leaves and the unfolding terminal bud of the shoot. In its early stage it has a cobweby appearance which soon becomes white and powdery from the development of the light conidial spores. Soon after this thin patches of the same character may be found upon the forming berries. Usually one side is more attacked than the other, and as the berry continues to grow it becomes one-sided or curved, because the fungus retards the development upon the infested side. If the berry is entirely covered its further development is generally checked. Later in the season the leaves, and especially their petioles and the young stems bearing them, turn to a rusty-brown color and become thickly coated with the fungus. The berries at the same time are covered with brown patches of mycelium which may be readily peeled off from the smooth skin of the fruit.

(d) THE SUMMER SPORES, CONIDIA.

A small portion of the mildew in its conidial stage is shown in Fig. 1. Only a few of the filaments making up the felt-like coating are represented. At intervals along these horizontal threads, branches are given off which rise vertically and soon begin a process of cross division, thus producing the conidial spores. Four of these aerial branches are shown (Fig. 1, *a*), one of which is still young, while the others are fully grown and spore-bearing. The spores (Fig. 1, *b*) as they form by this simple method of division fall from the tips of the threads and new ones continue to be formed from below. There is therefore an indefinite succession of spores from the same filament, the number depending upon the surrounding circumstances. These spores are colorless, and when produced in large numbers give the infested surface of the host a white, powdery appearance, as previously mentioned. They are borne exposed in the greatest possible degree, and may be readily scattered by the wind and in other ways. These spores quickly germinate when they fall upon a moist place on the surface of the host and produce new horizontal threads, which soon develop new vertical branches (conidiophores) with their spores.

(e) THE WINTER SPORES OR ASCOSPORES.

The formation of the sexual or ascospores may begin soon after the conidial spores appear, but usually they follow late in the season, and in many species (?) are not produced at all. With the gooseberry mildew they begin to form early in the life of the fungus, and by June may be found of full size. The initial stage in this formation is shown in Fig. 3, Plate XI. At a point where two of the horizontal filaments come near each other lateral branches are given off, one from each filament, One of these is slender and does not differ in appearance from the rest of the filament (Fig. 3, *a*). The other outgrowth soon becomes swollen and sometimes nearly pear-shaped

(Fig. 3, *b*). This is the female cell, the protoplasmic contents of which are fertilized by the commingling with them of the contents of the upper cell of the slender filament which is usually applied to the upper end of the female cell. The upper cell of the male organ contains a substance which corresponds in function to that within the cell coat of a pollen grain, while the female cell answers to the germ cell within the embryo sac of a young ovule. The process of fertilization in the gooseberry mildew is essentially the same as that with any ovule among flowering plants, but stripped of all the appliances seen in intricate blossoms, and therefore reduced to the simplest terms. The rapid propagation of a flowering plant by runners, suckers, bulbets, or by one or more of a long list of non-sexual methods, may be considered as homologous with the vegetative process in the mildews, including the production of the conidial spores. The latter are formed by a slow process of budding. As the result of fertilization in the young ovule there arises the seed and whatever may surround the seed or seeds, namely, the fruit. In the same manner the product of fertilization in the mildew under consideration is a "fruit" which includes the spores and their surroundings. The first evident result of fertilization in the mildew is the outward and upward growth of numerous short filaments from the base of the female cell. These threads soon completely surround the fertilized cell within and become divided by cross-walls, so that the young forming perithecium or spore case assumes the form and appearance shown in Fig. 4, Plate XI. If a section should be made through the middle of one of these nearly spherical bodies the view would show the outside cell situated upon a short stalk and occupying the center of the sphere. Later on in the development of the perithecia the outer coat becomes thicker by increase in number and size of the cells composing it, and assumes a dark chestnut color. At the same time some of the surface cells produce slender outgrowths which become as long as the diameter of the perithecium, and serve to hold it in place among the vegetative filaments of the mildew upon the surface of the infested host.

The perithecium at this stage is shown in Fig. 5, Plate XI. While these changes have been going on exteriorly the central protoplasmic contents have been shaping themselves into eight small masses, around which was formed a thick, colorless cell wall, called the spore sac or ascus. In Fig. 6 is shown a mature perithecium, the dark thick wall of which has been broken open by pressure, and the ascus is escaping from within. An ascus is shown in Fig. 7 more highly magnified and free from the perithecium.

On account of the prevailing chestnut color of the ripe perithecia the older portions of the mildew lose their white appearance and become of a dirty brown color. It is therefore easy to determine the condition of the mildew from the general appearance of the infested spot. The thick wall of the perithecium is for protection, and the spores within do not germinate until after a period of rest, during which time the surrounding covering becomes decayed or the spores escape by a rupture of its walls. The mildew passes the winter in the ascosporous condition, just as many of our annuals, like corn, etc., have their vitality concentrated within the seeds or grains that were formed by the mother plant in autumn. These winter or sexual spores find their way to the young, moist surfaces of the growing host plant during the following spring or summer, and these germinate and begin a new mildew spot.

(*f*) PYCNIDIA.

There is a third form of spore among the Powdery mildews. This is borne in pear-shaped bodies called pycnidia, and may be found among the filaments along with the young perithecia. The pycnidia of the gooseberry mildew are as shown in Fig. 2. The slender spores escape in great numbers through a pore near one end. These spores are doubtless for the rapid propagation of the fungus during its growing season.*

(*g*) CONDITIONS OF DEVELOPMENT AND REMEDIES.

As to the conditions favoring the growth of the gooseberry mildew the following quotations are offered from standard works upon fruit culture. Barry† says:

> In northern New York, in Maine. Vermont, and Lower Canada the finest large English varieties are brought to greater perfection than in warmer districts, and with good culture almost come up to the English standard. In a cold, damp, bottom soil at Toronto, almost on a level with Lake Ontario, fine crops are produced with comparatively little difficulty from mildew or rust. This would indicate as a remedy a cool soil and situation, and mulching the roots to keep them cool.

The last report of the American Pomological Society indicates, by a table of States, that the gooseberry is grown generally between the 35th and 45th parallels of latitude where there is a sufficient average rain-fall. Only a few States carry the double star for any variety, which is the index for their successful culture. Massachusetts, Michigan, Ohio, and Tennessee have each two varieties with two stars, and those States may be taken as indicating the range of territory best suited to gooseberries. Mr. Thomas‡ writes:

> Manuring, high culture, and pruning will in some cases prove sufficient to prevent mildew. This may be assisted by the cautious application of salt, either thinly over the soil or directly upon the plant; in the latter case the solution should be so thin that the saline taste may just be perceptible. Shading by a thick coat of salt hay appears to be an efficient remedy. It should be spread in a layer of several inches, or even a foot, in thickness, crowding it down to make room for the branches. This should be done in the spring.

Mr. Roe§ thinks that "repeated applications of the flowers of sulphur over the bushes from the time the fruit sets until it is ripe is probably the best preventive." Mr. Fuller‖ devotes the most space to the consideration of the gooseberry mildew, and says:

> There are many remedies which have been from time to time recommended, and they often appear to be effectual, while in other instances they are of no use whatever. The following remedies against mildew are worth trying, although they can not be called radical cures. Scatter flowers of sulphur over the bushes soon after the berries have set, and repeat the application occasionally until the fruit is ripe. Water the plants with strong soap-suds, or dissolve 1 pound of potash in a barrel of water and then sprinkle the plants once a week with it. Soak fresh-mown hay in brine for twelve hours; then cover the entire surface of the soil about the plant with this as a mulch. If hops, tan-bark, or other mulch has previously been applied, then sprinkle it with salt; a single handful to each plant will be sufficient. All of these remedies will often fail, but still they are worth trying. Old plants are more liable to suffer from mildew than young ones, therefore it is best to keep a supply of fresh

*See foot note, page 375.
†Barry's Fruit Garden, page 477.
‡American Fruit Culturist, page 162.
§Success with Small Fruits, page 226.
‖Small Fruit Culturist, page 227.

plants always on hand; in fact, so long as you can keep the plants growing vigorously there is but little danger from mildew. I have often seen the foreign varieties doing splendidly in half-shady situations, such as the north side of a wall or fence, or in the shade of trees, but such a situation can not be recommended as the best, because mildew does destroy plants under just such circumstances. No effectual remedy can be given, nor the best locality pointed out, because the experiences of different cultivators are so conflicting that the one that appears to be the best in one locality would seem to be the poorest in another. Wherever the foreign kinds will grow without being attacked by mildew they are certainly far preferable to any of our native sorts; but my own remedy against mildew is to cultivate none but the native varieties, for with these I have never experienced the least trouble nor, as yet, had a berry affected by disease of any kind.

Mr. Fuller names Cluster, Downing, Houghton, and Mountain Sweet as the best American varieties.

From all that has been written and said upon the subject it is evident that the climate of our country is remarkably favorable for the development of the gooseberry mildew and especially upon the foreign varieties which are so successful in England and where upwards of two hundred "gooseberry shows" are held in a single season. Our wild species of gooseberry are better adapted to the peculiar climate that here obtains, and, even though some of them do mildew, it is evident that the leading steps of progress in gooseberry culture, must be taken by developing our native stock through judicious culture, breeding, crossing, etc. The European horticulturists started with native wild species and have achieved wonderful success, and it may be true that remarkable results may be obtained in this country. This would be striking at the root of the matter.

Until the experimenter can develop a variety that will withstand the mildew perfectly, the gooseberry-grower must resort to one or more of the standard remedies. It has been shown that the trouble is one confined to the surface and may be quite readily reached by fungicides. The gooseberry mildew is very similar in structure and habits to the Powdery mildew of the grape, and it is doubtless true that the same remedies will prove effective in both cases. The writers of fruit culture who have been quoted in this paper are in favor of placing flowers of sulphur first upon the list of remedies for the gooseberry mildew. They are perhaps not sufficiently emphatic in the statement that this substance should be applied early in the season and repeated at frequent intervals for two or three months.

It is evident that whatever is employed to destroy this mildew will be most effective when applied while the spores are least protected. Therefore, the remedy should be applied for killing the conidial spores just before they begin to ripen and for the ascospores before they become surrounded by the thick perithecial wall. The best time is when the perithecia are beginning to form and are still in a soft, tender condition. Best of all, the fungicide is most effective when applied while the mildew is first beginning to establish itself upon the host. This would be the application of the well-established principle of an ounce of prevention being worth a pound of cure.

The trouble is a living plant and, therefore, no rule can be laid down as to the dates of applying the substance to destroy it. It is a safe rule to sulphur the bushes as soon as the first leaves are fully formed, and repeat the process every ten days during the most rapid growth of the canes. This rule would cover the period of flowering and the early development of the fruit. If the young leaves and stems can be kept free there will be only little occasion for sulphuring the young fruit.

A preparation of sulphur, lime, and water called "liquid grison" has proved an effective remedy for the powdery mildews. Three pounds each of sulphur and lime are boiled in 6 gallons of water until the whole is reduced to 2 gallons. The clear liquid is poured off from the top and mixed with 100 parts of pure water, when the remedy is ready for use. The preparation is best applied through a spraying watering-pot or hose pump with a fine nozzle. This subject is fully treated under "powdery mildew of the grape" in Bulletin No. 2 of the Botanical Division, pp. 26–28. The gooseberry-grower who is troubled with the mildew should try one or more of the recommended remedies for the downy mildew of the grape, and note the results. The following is especially urged for trial: 1 pound powdered sulphate of copper, 10 pounds air-slaked lime, and 15 pounds flowers of sulphur. Mix thoroughly and apply with a sulphuring bellows. Evident success in the treatment of this disease has attended the use of sulphide of potassium. Spray the bushes when first attacked with a solution containing one-half to 1 ounce of the sulphide to the gallon of water.*

The Powdery mildews are lovers of dry, hot weather, and therefore care must be observed not to credit to any particular remedy what belongs to the season. Remedies need to be tested for a term of years to establish their value. With a proper use of fungicides and the improvement of our native species of *Ribes* and their crosses with foreign sorts, there is no reason why gooseberry culture may not be profitable in the United States.

14.—Smut of Indian Corn.†

Ustilago Zeæ-Mays.

(Plates XII, XIII, XIV, XV.)

(*a*) HISTORY.

Corn Smut, in common with the smuts of other cereals, has received the attention of agriculturists and botanists from an early time. The earliest article in which Corn Smut is distinctly treated and given a name was published anonymously in 1760; the name was *Lycoperdon Zeæ*.

Most early writers and even some in the first quarter of this century considered smuts to be excrescences or degenerations, products of the plant or a symptom of sickness. Linnæus and Jussieu, however, recognized them as plants. The Corn Smut was long considered only a variety of the wheat smut and first was designated a variety in 1805 by DeCandolle,‡ who called it *Uredo segetum*, var. *Mays Zeæ*. In 1808 this author refers it, apparently for the first time, to the subgenus *Ustilago*, and under that subgenus it is called *Uredo segetum* var. *Zeæ Mays*. In 1815 he recognized it as a distinct species and called it *Uredo Maydis*.

The first mention of it as an American fungus appears to be that of Schweinitz,§ in 1822, by whom it was called *Uredo* (*Ustilago*)

*Arthur, Sixth Rept. N.Y. Exper. Sta., 1887, p. 348.
†By A. B. Seymour.
‡Fl. Fr., II, 596.
§ Syn. Fung. Car., p. 71.

Zeæ and described as occurring in the ear. Some peculiarities in the description led Link, Tulasne, and European botanists who have followed them to suppose that it was different from the European form. Tulasne therefore called the American form *Ustilago Schweinitzii,* and in this he has been followed by Fischer de Waldheim in his recent works. But Ravenel,* as early as 1848 (the year after the publication of Tulasne's paper), stated that Schweinitz's and Tulasne's names were synonyms.

In the practical study of smuts, Prevost appears to have been the first to gain any valuable results. In 1807 he made the first observations on the germination of the spores and maintained that the smut as a parasitic fungus was the cause and not a mere accompaniment of the disease.

Meyen, in 1837, first studied the spore formation in the corn. His observations were partly confirmed by Léveille two years later. This was more fully made out by DeBary and published in 1853. In 1858 Kühn published the results of his investigations, which were quite complete as regards Indian Corn Smut. He left undetermined the mode of entrance of smuts into their host plants except of the bunt of wheat. This was discovered by Wolff for wheat smut and several other species, and soon afterwards by Kühn † for Indian corn. This apparently completed the cycle of development, but it was left for Brefeld to discover a mode of germination and growth wholly unsuspected. In previous attempts to germinate the spores they had been placed in water or a moist atmosphere. Brefeld sowed them at first by accident, in a nutrient solution, an infusion of manure. His mass of dry spores was accidently thrown to the floor, and a dust-like cloud of spores was scattered throughout the room. Some fell into a nutrient solution which was in use for other cultures and there germinated. This experiment was afterward repeated many times with the same result. They grew by budding like yeast and could continue to grow in that manner for an indefinite period; but when the nutriment was exhausted they would form mycelial hyphæ in the normal manner.‡

(*b*) EXTERNAL APPEARANCE.

(Plate XIII.)

There is nothing in the external appearance of the corn to indicate the presence of a parasite in its tissues until about the time of flowering. Then it shows itself in the form of swellings of such a nature that the Germans call it "boil smut." These swellings vary in size from that of a pea to more than that of a man's fist, and mark the place where the spores are formed. With few exceptions all the kinds of smuts, over one hundred in number, form their spores in some definite place in the plant, most commonly in the floral organs. Corn Smut is the most marked exception to this, for it forms its spore masses in any part of the plant except the roots.

* Fung. Car. Exs., IV, 100.
† Bot. Zeit., Vol. XXXII, p. 122.
‡ For fuller accounts of the history and literature of the smuts the reader is referred to the works of Tulasne, Fischer de Waldheim, and Brefeld.

FIG. 3.—Staminate flowers (tassel) infested by smut (after Peck).

The stem sometimes bears spore masses close to the surface of the ground, as stated by Kühn, and as observed also by the writer. From this place to the tips of the tassel they may occur at almost any point. The ear is oftenest affected, especially the grains of corn upon the ear (Plate XIII, Fig. 1). It is rare that all the grains are affected at once; there are almost always some good ones. The bracts at the base of the ovaries or young grains become greatly distorted (Plate XIII, Figs. 1–14), and the husks inclosing the ear much more so. When the smut forms a ring around the middle of the ear the grains above are often aborted (Plate XIII, Fig. 1). In the staminate flowers (tassel) the swellings are not so large. The presence of the fungus does or sometimes does not prevent the formation of pollen, and the swelling which precedes the appearance of the powdery mass is not usually formed till after the pollen ripens.

Less frequent, but by no means rare, are the spore masses in stems, leaves, and sheaths. Those on stems (Plate XII, *b*) often have a considerable size, but upon leaves especially they are smaller and less luxuriant in appearance, sometimes no larger than a pea.

The form of the swellings is in general rounded oblong, but usually broader at the free end and narrowed at the point of attachment. They are covered by a whitish or lead-colored membrane, tightly stretched at first, but later becoming wrinkled and bursting to allow the escape of a mass of powdery spores (Plate XIII, Fig. 13). If a swelling is cut open when young it appears slimy and spongy; in color uniformly whitish. An older one will be found to contain certain blackish spots or stripes (Plate XIII, Figs. 3, 8, and 14), and at length the whole mass becomes blackish-brown. At this stage the membrane bursts and the spores are blown away.

(*c*) THE FUNGUS.

The fungus is found within the corn plant when the latter is quite young, and during the vegetative period, up to the time when spore formation takes place it consists only of mycelium. This necessarily begins its growth near the surface of the ground, since it enters when the corn is very young, and as the latter grows in height the mycelium also grows upward toward the place where it is afterward to form its spores. It lies mostly parallel to the part in which it is growing, and in soft tissues extends as a uniform thread for a distance equal to the diameters of several plant cells; but at intervals, especially where the cell walls are firmer, branching takes place (Plate XIV, Figs. 1 and 2), and a plexus of filaments is frequently formed, as are also haustoria or suckers, the special organs for absorbing nutriment. These are most abundant in the leaves. The thicker the cell walls which the mycelium penetrates, the more plentiful are the suckers. The cob of a diseased ear contains numerous mycelial threads, penetrating between and through the cells, and is a favorable place for microscopic examination. The tips of mycelial threads are quite pointed and firm, which enables them to penetrate cell walls (Plate XIV, Fig. 2). When young the mycelium is so deli-

cate that it is seen with difficulty, but when older the walls of the filaments are thick and have a double contour, as of a tube within a tube, and the protoplasm is to be seen in the middle (Figs. 2 *a*, and 3). The color is a peculiar glistening opalescent or bluish-white; but the threads are often enveloped by a coating of cellulose and obscured by it so as not to be easily detected. It is difficult to trace the fungus from the place of entrance to that of spore formation because the intermediate mycelium dies out or is absorbed.

The fruiting time of the corn is also that of the fungus; and its spores are most commonly formed upon the young kernels or contiguous parts.

(*d*) SPORE FORMATION.

(Plate XIII, Figs. 15-17, and Plate XIV, Figs. 5-12.)

The first step toward spore formation is the branching of the mycelial threads in the place where spores are to be formed. The spore-forming threads branch in a bush-like manner, and the branches formed are very slender. These, in their turn, branch repeatedly; at length a very complicated mass of branches is formed. This increase in the fungus causes the swelling of the plant, and the maturing of the spores completes the swelling. The latter consists, in addition to the mass of fungus threads, of an abnormal multiplication of the tissues of the host plant. The tips of the branching threads become swollen and distended with protoplasm and have a color and appearance similar to that of the mycelium; in this protoplasm granules appear, each of which is to become a spore (Plate XVI, Figs. 9–11). These gradually increase in size and the filament becomes considerably distended, so as to resemble a short string or cluster of beads.

The development is now very active, and lateral protrusions or short branches are frequently formed. Soon cell walls are formed across the filaments, one between every two of the nuclear formations. The distending results in a roundish cell for each of these. The cell walls become gelatinous, which gives the slimy character to the mass of smut. As the spores approach maturity the gelatinous walls are gradually absorbed, as are also the mycelial threads, so that at maturity very little remains but the dry, dusty spores. Those in the center of the mass mature later than those outside, and when the latter are dry the former may be found still slimy.

The spores (Plate XIII, Fig. 17) are globose or roundish-oblong in form, and the central mass of protoplasm is inclosed by a double wall, the inner colorless, the outer brownish-black and thickly covered with slender points. This outer wall is similar to that of pollen grains. Their size is from .00036 inch to .00048 inch (9μ to 12μ), or about 25,000 laid side by side would measure an inch.

(*e*) GERMINATION.

Vitality of spores and time of germination.—Kühn states that the spores germinate with difficulty or not at all in water, but that in a moist atmosphere they germinate readily in October, and reach the formation of conidia in twenty-four hours. Fischer de Waldheim obtained similar results. Brefeld also failed to germinate the spores in water in the fall. He found, however, that in the spring ger-

mination took place in water very readily. He holds this to be the general rule. In April one-half the spores used in the experiment germinated in water in two days. According to his observations spores will retain their vitality for as long as two years. At that age they will not germinate in water, but will germinate in a nutritive solution. This takes place less readily than when they are about six months old, but having germinated they grow with as great activity as fresher spores.

Manner of germination.—When the spores germinate in water or a moist atmosphere the process is as follows: The inner coat and contents swell, burst the outer coat, and protrude as a tube (Plate XIV, Fig. 12, *a–d*) called the promycelium, into which the protoplasm passes. Several cross partitions are formed, dividing the filament into several cells. At these and at the tip spore-like bodies, conidia or sporidia, are formed (Plate XV, Fig. 1). In many species of smuts the sporidia unite or conjugate in pairs; their contents coalesce and from the resulting body a filament grows which may enter the tissues of the proper host plant. The Corn Smut, however, is especially characterized by the absence of this process. The sporidia germinate singly and produce mycelial threads (Plate XV, Fig. 4, *a*), which may penetrate the tissues of the corn plant.

This is the normal mode of germination, but another mode, discovered by Brefeld, is of great scientific interest and practical importance, and to neglect to consider it in practice may render all remedial efforts useless.

When the spores were sown in a nutritive solution the conidia did not germinate by tubes, as described above, but by budding like yeast (Plate XV, Figs. 3 and 4). The cells soon become detached from the spore, and the growth continues in this manner, each conidium producing, by budding, bodies like itself, which become detached and in turn form buds as before, and the entire growth is of this kind (Plate XV, Fig. 4).

But if the nutriment becomes exhausted, these yeast-like cells form mycelial filaments which bear conidia as when the spores germinate in water (Plate XV, Figs. 5 and 6). Brefeld's experiments were frequently made in a drop of the nutritive fluid, in order to keep them within bounds for microscopic examination. In some cases the experiment was varied by adding another drop when the nourishment in the one was exhausted, and when this was done the budding growth was renewed and continued as before. It was found that this mode of growth would go on indefinitely if nourishment was within reach of the fungus. This same thing has been found to take place in nature, in the dung of animals that have eaten smutty corn, and the same may be expected to take place when any smutty corn finds its way into manure piles. Thus its vitality may be preserved indefinitely, and it is ready to form mycelial tubes and enter the corn when the latter is planted in ground fertilized with such manure.

This form of the fungus being in active growth is perhaps in better condition to seize upon the young corn than the spores are, especially after the first spring.

Manner of entering the host.—For a long time all efforts to discover how the fungus gained entrance into its host were unsuccessful, except in the case of the bunt of wheat observed by Kühn. The mycelium was found in very young corn plants and hence was believed to gain entrance at some part of the plant near the surface of the ground. Wolff finally observed the penetration of several species of

smut, including that of wheat. It was Kühn* again who, sixteen years after his first results were published, finally discovered the penetration of the mycelium of Corn smut into its host. He found that mycelium from the germinating spores entered at the root node and the lowest joint of the stem, *i. e.*, at the most tender part, and only when the corn was young; when it is old the smut apparently can not get in. This may be turned to practical account in preventive measures as described under remedies.

(*f*) DISTRIBUTION AND SEVERITY.

Prof. William Trelease has recently found Corn Smut growing upon *Euchlæna luxurians.* With this exception it is confined to corn, so far as known, differing in this respect from *Ustilago segetum,* which grows on wheat, oats, barley, and various grasses.

It is distributed throughout Europe and America. In the cooler regions, what corn is cultivated is comparatively free from smut, but in regions well adapted to the culture of corn, it is often very destructive. In the valleys of the Rhine and Rhone it sometimes destroys nearly the whole crop. In the Rhine valley in 1880, the crop harvested scarcely replaced the corn used for seed. In the United States the extent of the injury is very variable. Mr. C. H. Peck records a case which occurred in 1868. He noticed a field of corn near Albany, N. Y., which just before flowering appeared as thrifty and promising as any in that county, but later almost every hill was attacked by smut, and at least one out of every four ears. It was especially injurious to sweet corn about Washington, D. C., in 1886.

Prof. B. D. Halsted† states that at Ames, Iowa, in 1886, the college corn-field had sixty-two hundredths of 1 per cent. of the ears smutted. Prof. C. E. Bessey states that a destruction of 15 per cent. frequently occurs, and in one field he observed 66 per cent. of the corn smutty.

It is generally believed that wet weather is favorable to smut, and that corn is likely to be, and is, badly damaged in a wet season. A correspondent of the Country Gentleman, in September, 1878, writes that a wet season has been accompanied by much smut. Tulasne states that in 1846, a dry season, the corn crop in the valley of the Rhone was partly destroyed, and says the smut may be very injurious in very dry years. Prof. W. H. Henry states that the smut was very destructive about Madison, Wis., in 1881, causing a loss of 5 to 25 per cent. of the whole crop, while in 1882 there was very little smut. The writer observed that corn was badly smutted in northern Illinois in the summer of 1881, which was very dry.‡

(*g*) NATURE OF INJURY CAUSED BY CORN SMUT.

During nearly the whole growth of the corn the fungus is growing within it. It produces little apparent effect until the time of fruiting,

*Bot. Zeit., Vol. XXXII, p. 122.

†Bull. Iowa Agr. Col., Nov., 1886. Professor Halsted writes me, the summer of 1887, like that of 1886, was a very dry one at Ames, and that in 1887 the smut was very abundant.

‡In many corn-fields in Texas, as far west as El Paso, I observed more or less Corn Smut the past summer. The season was very dry.—F. L. S.

but at all times it takes from the plant some of the materials the latter prepares for its own growth. At the time of fruiting the amount thus taken is very large, necessarily weakening the activity of the plant, and especially injuring such of the grain as is not directly infested and destroyed. This is very evident when the smut is formed in the middle of the ear and the grains above are aborted. But an ear having any smut at all is practically destroyed. It can not be fed to cattle, because the spores will get into the manure and spread the infection. Smutty fodder can not be used for the same reason. The smut is believed to be poisonous to cattle, and many cases of injury or death have occurred supposed to result from feeding smutty ears or fodder. In medicine Corn Smut is used to some extent in place of ergot, its action on the animal system being the same.

It is worthy of notice that the time of greatest injury to corn from smut is at the time of fruiting. It may be that the great effort on the part of the plant to mature its fruit leaves it less physiological power to resist the parasite, and it is at this time that an abundance of material suited to the growth of the fungus is formed, especially in the ear.

(h) TREATMENT.

It is as certain that Corn Smut can not originate spontaneously as that the corn itself must grow from seed. The destruction of the spores, then, means the reduction of the smut sooner or later; but co-operation over wide areas is necessary, since the spores are light and may be carried in the atmosphere more easily than ordinary dust particles. Any remedy must be thoroughly tried before being condemned for apparent failure (one year is not sufficient), and every source of error must be guarded against. However carefully the smut is cut out and burned, if manure with which is intermixed smut of previous years is applied to the land the remedy will probably be ineffective, because the spores germinate in the manure.

Destructive treatment.—Cutting out should be practiced intelligently and persistently, and farmers should co-operate. The smut should be cut out as early as possible as soon as it gives the first evidence of its presence by the swellings it produces and before any of the spores burst through the epidermis. Corn is probably the only crop in which the smut becomes evident long enough before maturity to make treatment effectual, or at least possible. As soon as the spores begin to break out they will be scattered far and wide over the whole field. Any ears that are partly smutted and are overlooked till the husking should not be thrown in with the rest of the corn, for two reasons: They will scatter their spores, and if in large quantities will injure the cattle eating them. If any smutty stalks are standing when the corn is cut they should not be cut with the rest, but kept separate and destroyed. Masses of smut are greedily swallowed by cattle with the rest of the corn, and are liable to produce disease and death. A correspondent of the Country Gentleman, September 12, 1878, reports the loss of several head of cattle and sheep from this cause. Diseased parts cut out should be completely destroyed, not thrown upon the ground nor into a manure or compost pile. The spores may germinate and grow for an indefinite period, as already shown, and when the manure is applied to the field they will be ready to seize upon young corn and pene-

trate its tissues. One writer suggests feeding to pigs; but this should never be done, for if the smut does not injure the pigs the spores will pass through the intestines without injury to themselves and infect the manure.

Farmers will urge that they can not afford the time or money necessary to cut out the smut. In answer to this objection Professor Bessey makes the following estimate:*

A 40-acre field should produce at least $800 worth of corn. There is rarely less than one smutty ear to one square rod. This amount would be 2 per cent. of the crop and would be worth $16. Each additional smutty ear per square rod destroys $16 worth of corn in the field. Will it not pay to save annually a loss of 2 per cent. and upward, and occasionally a loss of 15 to 25 per cent., $120 to $200, for a field of this size?

Selection of seed.—Much may be gained by selecting for seed the largest and most perfectly developed grains. Experiments have shown that this will insure a larger yield, and it is also true [?] that corn from such seed is less liable to suffer from smut. Weak plants can offer less resistance to the attack of the fungus, as a weak man can less effectively resist disease. Thrifty plants can better withstand the smut if it gains entrance, and are more likely to escape its entrance, because they more quickly pass the stage at which the smut is known to enter them.

Application of remedies.—Any outward application to the growing corn would be useless if it could be made, because the fungus is entirely within the tissues of the host until after the damage is done.

Various applications have been tried to destroy spores adhering to grains. They have been made for this purpose to wheat, and there is no apparent reason why a remedy whould not be as effectual in one case as the other. It seems to be generally agreed that lime water is not effective. A weak solution ($\frac{3}{4}$ per cent.) of sulphuric acid is recommended for corn by some German experimenters.

Copper sulphate (blue vitriol) has been most used and with good results. One experimenter with copper sulphate for Corn smut records that no perceptible benefit was gained. If he fertilized the field with manure in any way infected by smut spores, which is not unlikely, it would be a sufficient reason to explain the failure. The method of application which prevails in Europe differs from the American method. The former is fully described by Sorauer in his work on plant diseases. He recommends a weak solution and long soaking; a $\frac{1}{2}$ per cent. solution of sulphate of copper and sixteen hours soaking he considers best. The solution should cover the corn deeply enough so that none shall be exposed when the latter swells, and the mass should be stirred well and all the grains that float skimmed off.

Sorauer states that a 1 per cent. solution kills 4 per cent. of the seed in twelve to sixteen hours. After soaking, the grain is spread out on a flat surface to dry, and it should be sown soon afterwards. It is dry enough for hand sowing in a few hours and for the drill in twenty-four hours.

The practice in America is quite different. Strong solutions are used and the grain is immersed only a short time. The following descriptions of the process as applied to wheat are by men who have had practical experience and know how to make the treatment effective:

* Bulletin Iowa Agricultural College, 1884, p. 129.

From a published letter by Hon. Horace Davis, member of Congress from San Francisco, and the largest miller on the Pacific Slope:

In early times we were much troubled with smutty wheat, but have little now, owing to the use of blue-stone on the seed by the farmers. I have seen fields where part of the seed was treated with blue-stone and part not, and the difference was as plain as between a field of barley and of oats. It is hard to give any exact rule as to application; the most practical farmers tell me they use 6 pounds to each ton of seed-wheat. It is dissolved in water enough to wet this quantity of wheat, and the wheat is put into bags, say 50 to 60 pounds, and immersed in the solution for six or seven minutes, just enough to wet all the wheat. Then it is taken out and laid on sloping boards at the end of the trough to drain. The solution is put into a trough built for this purpose, something like a horse-trough. The bags are turned over frequently in this solution to insure the wetting of all the wheat. You can rely upon it that blue-stone is a dead shot for smut in California. By blue-stone I mean the sulphate of copper.

Extract from a published letter on this subject by Prof. E. W. Hilgard, University of California, College of Agriculture:

As regards the blue-stoning of seed-wheat, the solution used is as strong as it can be made at the ordinary temperature. Such a solution contains about 3 pounds of blue-stone to 5 quarts of water. The time of immersion varies somewhat; the most definite description given is that a half sack should remain in the saturated solution at least three minutes, and be turned about several times in the interval to make sure of wetting thoroughly. When a weaker solution is used the grain may be left with it until it begins to sprout. The sacks are usually left unopened until used for sowing. There is no drying done on purpose, unless it is to be used in the seed-drill. It will work perfectly with the centrifugal sower without drying. In general I would be in favor of the strong solution and short immersion. The work is then done quicker, and if the grain is afterward left in the sack for some hours the application is sure to be effectual. Again, the strong solution is more certain to render the grain distasteful to birds and insect enemies, and gives a margin for killing fungoid germs round about the young seedling. There seems to be little danger to the vitality of the seed from the blue-stone. Of course the blue-stone will not prevent the smut germs left over in the fields from previous seasons from attacking the developed plant. It simply kills the germs in [on] the seed that would otherwise develop along with the latter, and take the plant in its early stages. A field that has been very smutty during the previous season will be apt to show some on the grain of the next one despite blue-stoning, but persistence in the practice will be sure to put an end to the fungus germs, save so far as they may be furnished by kind neighbors above the wind.

Prof. M. A. Scovell, director of the Kentucky Experiment Station, writes as follows in the bulletin of the station of September, 1887, p. 14:

This disease (smut) was in all our wheat last year, consequently our seed-wheat contained smut grains. To prevent its recurrence this year all our varieties of wheat were treated with a solution of blue vitriol (blue-stone) before sowing. The method of applying the solution of blue vitriol was as follows: Ten pounds of blue vitriol were dissolved in 8 gallons of water, and the solution placed in a tub. The seed-wheat was put into the solution and well stirred, care being taken not to put enough wheat in to come to the top of the solution. After skimming off floating wheat and particles, the solution was poured off into a second tub, the wheat drained, and spread on boards to dry. The solution was re-used as often as we had wheat to treat in this manner.

This treatment proved entirely successful, not the least smut appearing in any of the plots where the seed had been treated in this way, while the plot planted for comparison, without treating the seed wheat, contained about the same amount of smut as last year.

It was thought that by having the solution cover the wheat the smut grains would float, and in this way all but adhering spores would be removed, and these would be easily killed by the copper sulphate solution.

All other preventive measures will be likely to be of little avail if the manure put upon the land is contaminated with smut spores.

from smutty corn fed to stock, or smutty stalks thrown into the manure pile, or from whatever source.*

Brefeld's investigations, described under germination, show how manure may spread infection. A direct demonstration of this point by Morini is quoted by Sorauer. Bran with which Corn smut spores were mixed was fed to a cow. The dung in which the spores were found germinating was put upon a piece of land with corn seed. The resulting growth of corn was, as a whole, smutty. Of thirty others dampened with gum water and covered with ungerminated spores only four plants were smutty. This shows the injury that may come from spores germinating in manure. It does not prove that passing through the animal makes them more active. In Brefeld's experiments, on the contrary, nearly all spores sown in a nutritive solution in the spring germinated within twenty-four hours. It shows that every precaution should be taken to keep the smut away from stock and out of manure piles. Burying the smut deeply suggests itself as a convenient and efficient means of disposing of it. Burning is effective, but care must be taken that spores shall not be carried away and scattered by currents of air about the fire. Rotation of crops should be practiced for evident reasons.

In Europe two other species of smut occur in Corn and both are most prevalent in Italy. *Ustilago Fischeri*, Pass., attacks the cob, and in Italy, especially about Parma, sometimes destroys half the crop.

Ustilago Reiliana was introduced into Italy on sorghum from Egypt, and in the former country it grows also on corn, attacking the flowers of the tassels.

15.—Corn rust.

Puccinia Maydis, Carr.

(Plate XVI.)

(*a*) history.

Mention of the Corn Rust is conspicuously absent in the works of leading mycologists in the early part of this century. Probably it was not common in Europe at that time and it may have been confounded with other species.

The only mention of it in those early years, so far as known, was by an Italian writer, Carradori,† whose name is scarcely known otherwise to mycologists. He described it in 1815 under the name *Puccinia maydis*. Schweinitz‡ (1834) is the next to mention it, and the first to record it as American under the name of *Puccinia sorghi*. Later several European botanists gave it names, each one supposing that he had found it for the first time. It causes less injury than

* When stable or barn-yard manure is used as a fertilizer a possible prevention of smut might be found in David's powder (see page 328).

Immediately previous to planting, the seed-corn should be wet, and while in this condition thoroughly raked over in the powder; or, a spoonful of the powder should be dropped along with the seed in each hill. Avoid handling the powder with the naked hands.—F. L. S.

† Gioru di Fisica, etc., del Brugnatelli, 1815, Vol. VIII. See Just. Jahresbericht, 1876, p. 152.

‡ Syn. Fung. Am. Bor., p. 295.

the smut and consequently has received less attention from practical men. Its life history has not been especially studied, but that of several related species have been studied very fully. The best practical article upon it in English is that by Mr. C. H. Peck in his thirty-fourth report.

(*b*) EXTERNAL APPEARANCE.

Corn rust is very similar to the rust of wheat, but still specifically distinct. It does not grow upon the floral organs, but so far as observed is confined to the foliage, where it appears as small pustules. After the middle of the summer the pustules begin to appear on either or both surfaces of the leaves. At first they are covered by the epidermis and are whitish, but they soon swell sufficiently to break the latter, whose lacerated edges may be seen standing up around them. Thus the pustules become exposed, and at the same time the spores which they contain are matured and ready to be disseminated. The pustules (called sori) are collections of spores. The sori are roundish, or oftener somewhat elongated in form, scattered irregularly; but sometimes they are clustered, and then they tend to be arranged in lines parallel to the length of the leaf.

The earlier pustules, if examined carefully, will be found of a bright, rich, yellowish-brown color; the later ones almost black.

(*c*) THE FUNGUS.

This difference in color indicates two different kinds of spores; but they are frequently found intermingled in the same pustule, and are produced from the same vegetative fungus threads (mycelium) within the leaf. The brown spores (uredospores), which are the earlier, correspond to the so-called red rust of the wheat. A section through a pustule shows that each spore is borne on a slender stalk, from which it easily falls. The shape is nearly spherical (Plate XVI, Fig. 2), and the comparatively thick wall or coat of the spore is covered with minute projections. The diameter is about one one-thousandth of an inch or a trifle more. In the protoplasmic contents drops of oil are sometimes seen. The vitality of the spores is of short duration. They must germinate within a limited time if at all. It is believed that they are killed by becoming dry, and that they do not survive the winter. The black pustules (Plate XVI, Fig. 1) are composed of dark-colored spores (teleutospores) having a very different structure and function. The stalks which bear them are stronger and do not separate from them. Each spore is broadly elliptical in outline, with both ends rounded, or with the apex occasionally thickened and pointed (Plate XVI, Fig. 3). The surface is smooth. A partition is placed across the middle which divides the interior of the spore into two cavities. At germination each part may germinate independently, so that this may be called a double spore. At the partition the spore is constricted and it is twice as long as broad; some are a half longer and broader than others, and the largest are a little narrower than the diameter of the uredospores. They measure .0006 to .0009 inch by .0012, to .0018 inch. These may be called resting spores, because they remain dormant through the winter and germinate the next season, again producing the rust and thus perpetuating its existence. It is not known to have any third form of spores (æcidium) such as the common wheat rust produces upon the barberry.

(*d*) SEVERITY.

The fungus is always injurious to the corn on which it grows, but the extent of the injury depends largely on the age and condition of the corn and climatic conditions, and is often so slight as to be of no practical importance. Certain conditions of the weather may retard the growth of the corn and favor that of the rust. Ordinarily the rust is not noticed till the latter part of the summer, when the corn is well grown and not easily injured; but in the first week of July, 1886, the writer observed it repeatedly on the lower leaves of partly-grown corn, whose vigor was plainly impaired by it.

The injury consists (1) in loss of food materials elaborated by the plant for its own growth, which the threads (mycelium) of the fungus, ramifying in the tissues of the corn, absorb for their growth and the formation of spores; (2) in destroying the power of some of the tissues to do their work, and of the chlorophyll contained in them to continue the elaboration of fresh food supplies for the corn. When coming early in the season the rust is likely to be more than usually injurious later in the same year, and to continue so the year following.

Thus far the experiments made in combating the rusts have yielded no positive results.

16.—Erinose.

Phytoptus vitis.

(Plate XVII.)

(*a*) GENERAL OBSERVATIONS.

The name Erinose is here adopted to designate a special disease of the leaves of the grape-vine caused by a minute acarid, the *Phytoptus vitis*. Formerly the peculiar effects produced by this *Phytoptus*, as well as those caused by other species which infest the alder, maple, beech, etc., were thought to be fungi, and were all included by the older mycologists in the genus *Erineum*. In the case of the vine, the effect produced by this little animal parasite bears a strong resemblance to the external appearance of the downy mildew, and samples have been sent to us from various parts of the country under the supposition that the leaves were infested with the Peronospora. As it is very important to be able to distinguish the one, which is always to be dreaded, from the other which rarely if ever does any serious injury, the peculiar characters of Erinose will be here pointed out.

(*b*) EXTERNAL APPEARANCE.

Erinose usually appears in early summer in the form of raised, lustrous white spots on the lower surface of the leaves. The color soon becomes yellow, and finally a dark reddish-brown. The spots, usually small and scattered irregularly over the surface between the nerves, are sometimes of considerable size, and we have occasionally found leaves of *Vitis æstivalis* with their lower surfaces entirely covered by Erinose. There is no evidence of the disease on the upper surface of the affected leaves in the wild or cultivated vines of the Eastern and Middle States. If attacked while young they

may be prevented from attaining a normal size, and when badly infested they become more or less curled, with the convex side uppermost. On the upper surface of leaves of *Vitis vinifera* and its varieties, however, the disease shows not in any discolorations, but opposite the spots beneath there are conspicuously raised areas imparting to the surface a blistered appearance. This results from a greater growth or multiplication of cells in the diseased areas than in the surrounding unaffected portions.

(c) MINUTE CHARACTERS (Fig. 1).

If the lustrous white, or later yellowish, spots are examined with a good lens or magnifying glass they will appear to be composed of a dense growth of shining hairs (Fig. 1, *a*, *a*), with somewhat enlarged tips, and this is their true character, as may be determined by a microscopical examination. There is no longer any danger of mistaking these hair-like growths for the downy mildew, for when viewed under the microscope there is not even the slightest resemblance between them, as may be seen by comparing Fig. 2, Plate XVII, of this report, with Fig. 10, Plate I, in the annual report for 1886. In the former figure, which illustrates a transverse section through one of the spots affected with Erinose, the microscopical characters of the disease are illustrated. The cells composing the tissues of the leaf are seen to be abnormal in their development, while the epidermal cells of the lower surface are elongated into hair-like projections, sometimes branched above, and with rounded and more or less club-shaped tips. The cause of this abnormal growth is the Acarid, two specimens of which (Fig. 2, *b b*) are shown in the figure equally magnified with the section. To the naked eye they are barely visible, even when placed upon a surface of contrasting color; it is quite impossible to detect them on the spots without a good magnifying glass. These parasites puncture the epidermal cells of the leaf, from the irritating or poisoning effects of which the abnormal growths and consequent spots are developed.

Phytoptus vitis lives mostly in the larval state, the condition illustrated in our figure. The adult stage is found only in the spring, and then but for a brief period. When it comes out of the egg it possesses four feet, situated upon the anterior part of the body, which is composed of several rings; the skin is striated and furnished with four stiff hairs upon each side of the body, and two long bristles are fixed in the posterior extremity. The larvæ multiply during the summer by means of parthenogenetic eggs (Fig. 2, *c*). At the approach of winter they become encysted and hibernate under the scales of the buds or in crevices of the bark. In the spring the cysts are ruptured and from them come six-footed larvæ, which soon develop two additional feet, thus passing into the mature stage. The adults die immediately after the eggs are laid, the latter giving rise to the four-footed larvæ above described.*

(d) DISTRIBUTION, EFFECTS, AND TREATMENT.

Erinose is widely distributed throughout the country, and may be looked for wherever the vine is cultivated. We have seen it in New Jersey, District of Columbia, Texas, and California. It is nowhere particularly injurious, and only in very rare cases does it ever make

* P. Viala, "Les Maladies de la Vigne," p. 451.

any difference in the quantity or quality of the crop. If, however, it attacks very young leaves it may be harmful and some treatment be necessary. Repeated applications of sulphur, made when the shoots are 3 to 5 inches long, will check the multplication of the *Phytoptus*. Washing the vines after they are pruned in early spring with boiling water will destroy the eggs and larvæ concealed within the bud scales and crevices of the bark.

F. LAMSON SCRIBNER.

Hon. NORMAN J. COLMAN, *Commissioner*.

EXPLANATION OF PLATES.

PLATE I.

STRAWBERRY-LEAF BLIGHT (SPHÆRELLA FRAGARIÆ).

FIG. *a*. Diseased leaf, natural size, attacked by the summer stage of the fungus. (G. M., pinx.)
FIG. *b*. Tuft of conidiophores and conidia which have broken through the upper epidermis. (E. A. S., del.)
FIG. *c*. Conidia more highly magnified; three of them have sent out germ filaments. (E. A. S., del.)
FIG. *d*. Perithecium bearing conidiophores around the ostiolum. (E. A. S., del.)
FIG. *e*. Section of perithecium, showing asci within. The asci are borne upon a small mass of parenchyma at their base. *a* Ostiolum. (E. A. S., del.)
FIG. *f*. Five asci containing ascospores; much enlarged. (E. A. S., del.)
FIG. *g*. Ascospores. (E. A. S., del.)

PLATE II.

APPLE SCAB (FUSICLADIUM DENDRITICUM).

FIG. 1. Shows the scab on the fruit.
FIG. 2. A leaf attacked by the scab fungus.
FIG. 3. A section through a portion of one of the spots on the fruit, showing the growth of the fungus; greatly magnified.
FIG. 4. Spores of the fungus, greatly magnified; four of them germinating.

PLATE III.

BITTER-ROT OF APPLES (GLŒOSPORIUM FRUCTIGENUM?).—LEAF-RUST OF CHERRY (PUCCINIA PRUNI-SPINOSÆ).—BEET-RUST (UROMYCES BETÆ).

FIG. 1. Section through piece of rotten apple showing an old pycnidium: *a*, thick epidermis of fruit; *b*, fruit perenchyma; *c*, mycelium in tissues. The hyphæ surrounding the pycnidium are composed of a series of short cells.
FIG. 2. Section showing pycnidium and hyphæ after the formation of spores has ceased; *a*, mycelium in fruit tissues.
FIG. 3. *A*, tuft of spore-bearing hyphæ; *a*, spore. *B*, spo es much enlarged; *a*, surface view; *b*, optical section.
FIG. 4. Germinating spores twenty-four hours in water; showing dark bodies formed on the germ filaments.
FIG. 5. Germinating spores eight hours in water.
FIG. 6. Uredospores of *Puccinia pruni-spinosæ* on peach.
FIG. 7. Same on plum: *a* and *b*, in germination; *c*, *c*, germ pores.
FIG. 8. Paraphyses found abundantly in sori of *Puccinia pruni-spinosæ*.
FIG. 9. Teleutospores of same on plum: *a a*, surface view; *b b*, optical section.
FIG. 10. Section through portion of sorus (uredo-stage) of *Uromyces betæ*: *a a*, cells of leaf tissue entirely surrounded by mycelium; *b*, ruptured epidermis; *c*, spores; *d d*, pedicels from which the spores have fallen. The mycelium masses together in spots beneath the epidermis forming a stroma on which the spores are borne.
FIG. 11. Uredospores of same: *a*, germ pore.

Plate IV.

COTTON-LEAF BLIGHT (CERCOSPORA GOSSYPINA).

FIG. 1. Diseased leaves, natural size. (R. C., pinx.)
FIG. 2. Showing a tuft of dark-colored fruiting hyphæ rising from the mycelium within the leaf and issuing through the epidermis. Above are shown the long, colorless, septate spores. (E. A. S.. del.)

Plate V.

ANTHRACNOSE OF RASPBERRY (GLŒOSPORIUM VENETUM).

FIG. 1. Branch, natural size, showing appearance of disease upon the cane and leaves, and its effect on the berries. The upper portion of the cane is quite dead, and the diseased spots extend down on the green portion, along the branch and stalk that bears the berries, and over the petiole and midribs of the leaf and leaflets. The berries remain unripened. owing to the effects of the disease. (R. C., pinx.)
FIG. 2. Section through a diseased spot on the cane, showing destruction of the outer layers of tissue, and the spores (*a*) borne on the surface and center of the spot. (F. L. S., del.)
FIG. 3. Spores, showing two in process of germination. (F. L. S., del.)

Plate VI.

ANTHRACNOSE OF THE BEAN (GLŒOSPORIUM LINDEMUTHIANUM).

FIG. 1. Diseased pods, natural size. (R. C., pinx.)
FIG. 2. Section through a diseased pod. The section is taken between two beans, consequently shows none in the cavity. The diseased portions (*a*) are dark colored; *b*, exocarp; *c*, endocarp. (E. A. S., del.)
FIG. 3. Another section through a diseased pod, showing an advanced stage of the disease and a diseased bean (*b*) inside the pod; *a*, diseased spot, one entire side of the pod is diseased and shrunken; *c*, small diseased spots where the fungus has not penetrated through the exocarp. (E. A. S., del.)
FIG. 4. Section through a fruiting pustule: *a*, ruptured epidermis; *b*, mycelium; *c*, conidiophores; *d*, brown hyphæ; *e*, spores. (E. A. S., del.)
FIG. 5. Spores, highly magnified. (E. A. S., del.)

Plate VII.

CATALPA-LEAF SPOT DISEASE.

FIG. 1. Section through leaf at the union of a diseased spot with the healthy tissue: *a*, healthy tissue; *b*, diseased spot, in which the cell outlines have almost entirely disappeared.
FIG. 2. Tuft of *Macrosporium catalpæ* emerging from a stoma; *a a*, spore-bearing hyphæ; *b b*, spores; *c*, very young spore.
FIG. 3. Germinating spores of *Macrosporium*.
FIG. 4. Pycnidium, or fruiting body of *Phyllosticta catalpæ*. The pycnidium is partially sunken in the tissues of the diseased leaf, and the spores are borne on rather long basidia which line the inside of the conceptacle.
FIG. 5. Spores, more highly magnified.
FIG. 6. Spores, germinating after forty-two hours in water.

Plate VIII.

BLACK SPOT ON ROSE LEAVES (ACTINONEMA ROSÆ).

FIG. 1. Diseased leaf, natural size. (R. C., pinx.)
FIG. 2. Enlarged portion of leaf at edge of spot, showing the apparently superficial mycelium and two fruiting pustules. (R. C., pinx.)
FIG. 3. Branching strand of superficial mycelium. (E. A. S., del.)

PLATE IX.

BLACK SPOT ON ROSE LEAVES (ACTINONEMA ROSÆ)—ROSE PHRAGMIDIUM (PHRAGMIDIUM SPECIOSUM).

FIG. 1. Section through healthy rose leaf: *a*, cuticle of upper surface; *b*, upper epidermal cells; *c*, two rows of palisade cells; *d*, loose parenchyma; *e*, lower epidermis; *f*, cuticle of lower surface. All except the epidermal cells are partly filled with chlorophyll bodies. (E. A. S., del.)

FIG. 2. Section through rose leaf attacked by *Actinonema*, showing an early stage of the disease. The upper epidermal cells are partly filled with a dark, homogeneous mass, consisting of the transformed cell contents; the chlorophyll bodies in the upper row of palisade cells are disorganized, and the process of disorganization has begun in the lower row; *a* shows the hyphæ between the cuticle and the epidermis; *b*, cuticle that has been ruptured by the formation of spores beneath; *c*, spores borne on an indistinct mass of mycelium; *d*, the mycelium can be seen in the cells of the upper epidermis, and evidently pushes into or between the palisade cells, although it can not be distinguished below the epidermis. (E. A. S., del.)

FIG. 3. Very advanced stage of the same. The disorganization of cell contents has progressed through the leaf, and the cells are shrunken so as to show the mycelium between them. Most of the spores have escaped from the fruiting pustule. (E. A. S., del.)

FIG. 4. Spores of same, much enlarged. (E. A. S., del.)

FIG. 5. Teleutospore of *Phragmidium mucronatum*, showing long stalk thickened towards the base. (F. L. S., del.)

FIG. 6. Fragment of rose stem affected by *Phragmidium speciosum*. (R. C., del.)

FIG. 7. Teleutospores of *P. speciosum*. (F. L. S., del.)

FIG. 8. Same, more enlarged and without pedicel. (F. L. S., del.)

PLATE X.

ROSE RUST (PHRAGMIDIUM MUCRONATUM).

FIG. 1. Branch of *Rosa blanda*, natural size, showing appearance of the disease in the Æcidio-stage on the stem and leaves; at *a* the branch has been bent from the effects of the fungus. (R. C., pinx.)

FIG. 2. Leaf attacked by Uredo and Phragmidio-stages; the latter is represented by the darker spots. (R. C., pinx.)

FIG. 3. Æcidio-stage. Section through diseased spot occurring on a vein; the spores are borne in chains over the back of the vein, and a few paraphyses (*a a*) may be seen at the circumference of the spot. (F. L. S., del.)

FIG. 4. Uredo-stage. Cluster of spores and paraphyses. (F. L. S., del.)

FIG. 5. Æcidiospores. (F. L. S., del.)

FIG. 6. Uredospores, separated from their pedicels. (F. L. S., del.)

FIG. 7. Teleutospores.

PLATE XI.

POWDERY MILDEW OF GOOSEBERRY (SPHÆROTHECA MORS-UVÆ).

FIG. 1. Mycelium with conidiophores and conidia in rows, as found on the surface of the leaf: *a*, conidiophore; *b*, conidium. Two conidia are represented as having become detached.

FIG. 2. Three of the so-called "pycnidia" of the fungus. Two are represented as discharging their spores. (After Tulasne.)

FIG. 3. The male (*a*) and female (*b*) cell united for the production of the perithecium.

FIG. 4. A young perithecium.

FIG. 5. A perithecium nearly full grown, showing appendages.

FIG. 6. Ripe perithecium broken open and the spore sac (ascus) coming out.

FIG. 7. An ascus, showing the eight spores.

PLATE XII.

SMUT OF INDIAN CORN (USTILAGO ZEA-MAIZE).

FIG. From photograph, illustrating the appearance of the disease in the ear (*a*) and on the stalk (*b*).

PLATE XIII.

SAME (AFTER TULASNE). ILLUSTRATING THE EFFECTS OF THE DISEASE.

[Figs. 15, 16, and 17 represent the objects magnified about 460 times; all others natural size.]

FIG. 1. Portion of a smutty ear of white corn; at the base are some sound and ripe grains (*g*); above, the female flowers remain sterile (*s*), and the bracts merely cover the abortive ovaries; the bodies (*c c*) are bracts made numerous by the influence of the *Ustilago*, which is there developed.
FIG. 2. Young ovary inclosed by bracts and, like them, swollen by the presence of the endophyte; the style is strongly bent down on the inner side.
FIG. 3. Vertical section of these organs; the wall of the ovary is very thick on the outer side and thin on the inner; a rudiment of the ovule is situated at the base; the black spots in the thickness of the bracts and the wall of the ovary indicate the formation at these points of the black powder of the *Ustilago*.
FIG. 4. Another smutty ovary cut vertically, in which, besides the rudiment of the ovule, is found a thin membrane, ordinarily not smutty, and which is united below with the inner surface of the ovary.
FIG. 5. A bract or husk deformed and monstrously enlarged by the continued development of the smut in its tissue.
FIG. 6. Transverse section of this bract, in which the presence of the endophyte is indicated only in one part, although it occupies uniformly all the tissues of the organ.
FIG. 7. Another smutty bract.
FIG. 8. Transverse section of the same.
FIG. 9. Another of different form.
FIG. 10. Horizontal section of 9.
FIG. 11. Two smutty bracts partly united.
FIG. 12. Transverse section of Fig. 11.
FIG. 13. Another, more monstrous than the preceding.
FIG. 14. Horizontal section of 13 (sketch incomplete). The husks acquire, under the influence of the *Ustilago*, a much greater development than the ovaries, which sometimes fail almost completely.
FIG. 15. Fragment of the mucilaginous material of the *Ustilago*, in which are immersed innumerable spores not yet mature.
FIG. 16. Another fragment in which the spores are less developed than in the preceding; on one side of this figure are shown filaments such as are abundant in the cavities occupied by the endophyte.
FIG. 17. Dry spores.

PLATE XIV.

SAME, ILLUSTRATING THE MYCELIUM, ETC.

FIG. 1. Long, extended threads beginning to ramify, running through a pith cell (in which a nucleus is still to be seen). From the second internode below a blighted rachis.
FIG. 2. A long, extended thread covered with a cellulose sheath and passing through many cells. At *a* the thread shows through, at *b* is seen the section of the cut sheath and of the thread. Cut lengthwise through the rachis at the bottom of the ovary.
FIG. 3. The previous figure at *a*; a conspicuous piece of thread; in the thread is seen the contents; the cellulose sheath is strongly marked.
FIG. 4. Threads which have become distinctly visible in the cellulose sheath by the application of potash and iodine. Shown detached from a cell of the ovary wall.
FIG. 5. Thin-walled threads (like the transition form in the spore forming threads), with many shoots and fine-grained contents. Parenchyma of ovary wall cut lengthwise.
FIG. 6. Thread become gelatinous; the contents is indistinctly seen. From a gelatinous spore mass.
FIG. 7. Spore forming threads, with bright oleaginous contents running between the cells. Ovary cut lengthwise.
FIG. 8. Gelatinous thread, with a distinct breaking up of the contents for spore formation; the upper part represents the same conditions as Fig. 2. Its course between the cells was still, in part, distinctly perceivable.

FIG. 9. More transparent spores forming in the interior of the gelatinous thread.
FIG. 10. The same; however, a great number of the transparent spores are seen lying in a row, lengthwise in the stem. The latter appear more transparent.
FIG. 11. A spore become brownish, surrounded by the gelatinous membrane of the thread. From the ovary wall.
FIG. 12. *a*, promycelium with a projection; twenty-four hours; *b*, spore germination later with a straight promycelium; forty-eight hours; *c*, the same with the promycelium bent in a knee form; *d*, formation of a lateral sporidium (after twenty-four hours). Highly magnified.
FIG. 13. An affected ovary cut lengthwise; the masses of ripe spores appear as black spots or stripes.

PLATE XV.

SAME, GERMINATION OF SPORES IN WATER AND NUTRITIVE SOLUTIONS.

(Figs. 30-35, after Brefeld.)

FIG. 1. Germination of spores in water and bearing conidia.
FIG. 2. Older germinating spores. The conidia have fallen, some cells of the conidiophores have become empty, others have developed into filaments.
FIG. 3. Germination of spores in a nutritive solution, showing the more strongly developed conidiophores producing conidia from every cell; the conidia have also sprouted and bear other conidia.
FIG. 4. Development of a spore cultivated singly in a drop of nutritive fluid: *a*, the germinal tube formed; *b*, same, more fully developed and divided into cells by cross partitions; c^1, c^2, *b*, fallen pieces; c^1 and c^2 have produced conidia, *d d*, which, fallen from c^2, develop other conidia or yeast-like forms by continuing budding.
FIG. 5. Conidia forming filaments in an exhausted nutritive solution: *a*, thread full of protoplasm; *b*, filament partly emptied of protoplasm; *c*, conidia germinating while still attached together.
FIG. 6. A conidium which in germinating has protruded into air and apparently formed aerial conidia.
FIG. 7. Conidia which did not germinate to form filaments and in which oil globules have appeared: resembling spore formation.

PLATE XVI.

INDIAN CORN RUST (PUCCINIA MAYDIS).

FIG. 1. Transverse section of corn leaf through a cluster of teleutospores, showing also the ruptured epidermis and mycelial filaments among the leaf cells.
FIG. 2. Uredospores, three viewed in optical sections showing germ pores and thickness of wall; a fourth showing surface view.
FIG. 3. Teleutospores.

PLATE XVII.

ERINOSE.

FIG. 1. Lower surface of leaf attacked by Erinose. (After Corda.)
FIG. 2. Cross-section of grape leaf through one of the galls of *Phytoptus vitis*, showing the hairs (*a*) formed from prolonged epidermal cells, two of the animals (*b b*), and one of the parthenogenetic eggs (*c*). (E. A. S., del.)

THE HATCH LITHO CO N.Y.

STRAWBERRY LEAF BLIGHT

GEO. MARX FECIT. THE HATCH LITHO CO. N.Y.

APPLE SCAB.
Fusicladium dentriticum.

BITTER-ROT OF APPLES. LEAF-RUST OF CHERRY. BEET-RUST.

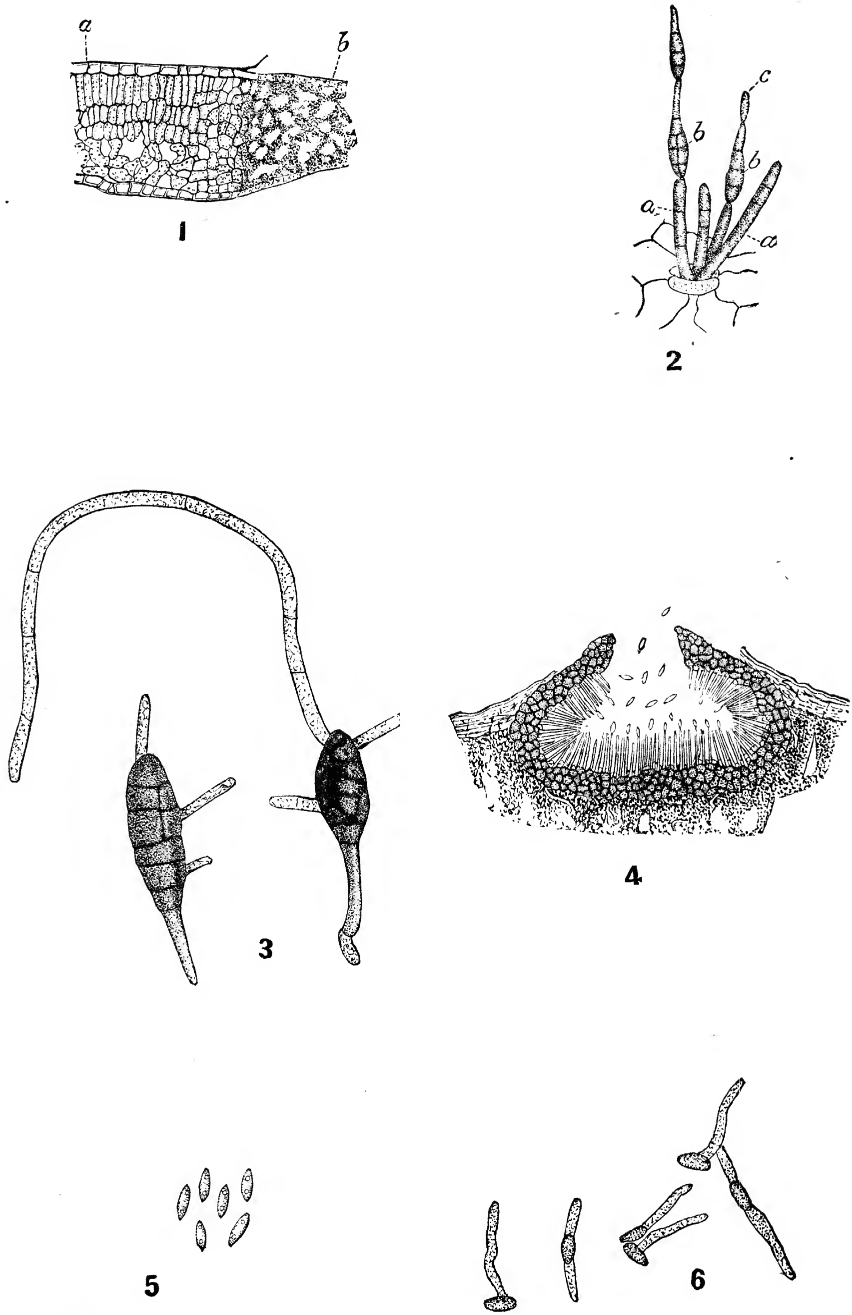
R GOWING THE HATCH LITHO CO N Y

COTTON - LEAF BLIGHT.
(Cercospora gossypina, Cke)

ANTHRACNOSE OF RASPBERRY.

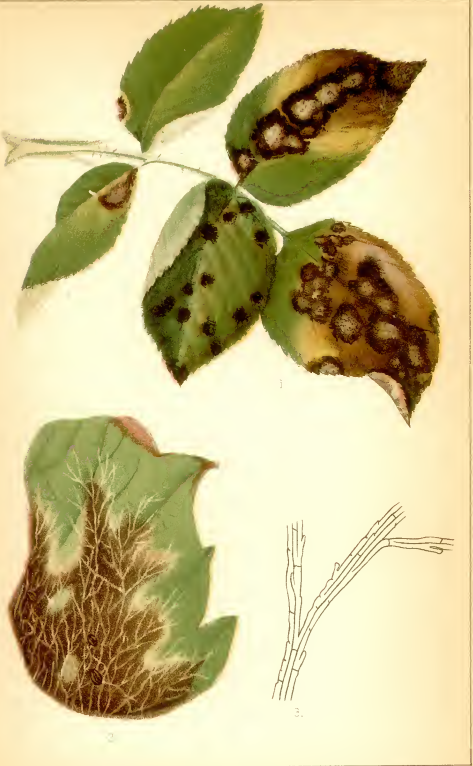
R. COWING
THE HATCH LITHO CO N Y

ANTHRACNOSE OF THE BEAN

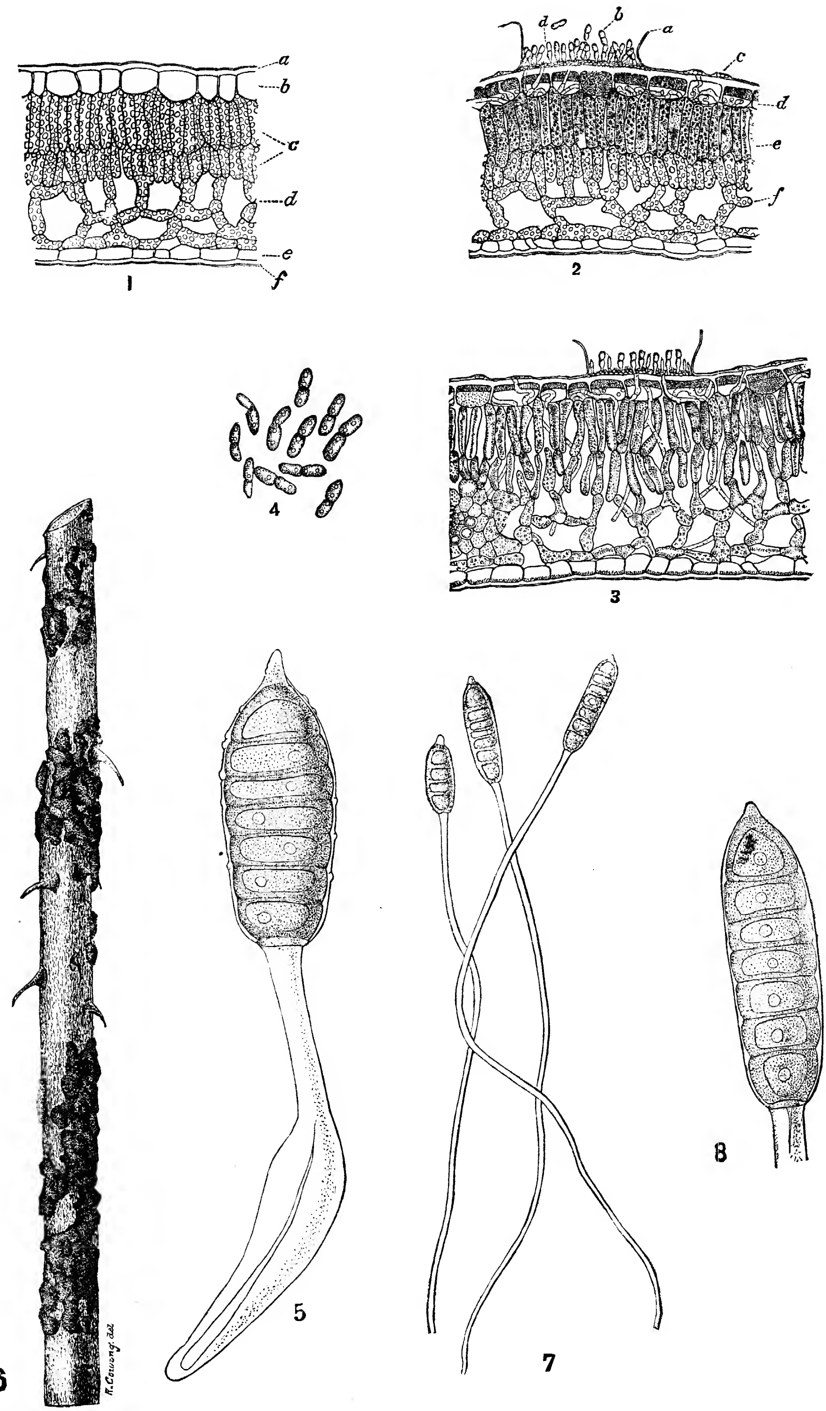


E. A. S. del.

LEAF-SPOT DISEASE OF CATALPA.

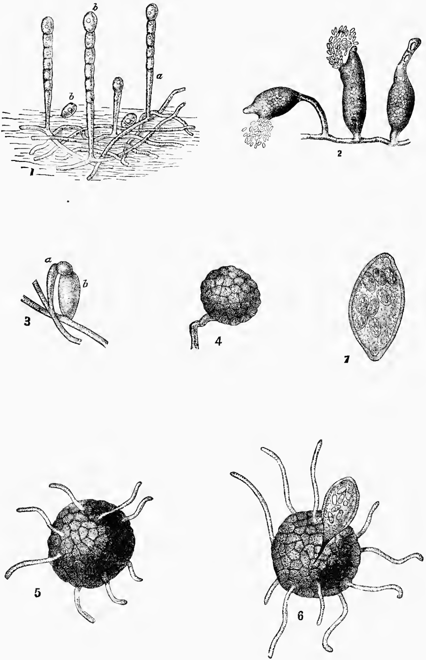


BLACK SPOT OF THE ROSE
Actinonema rosae



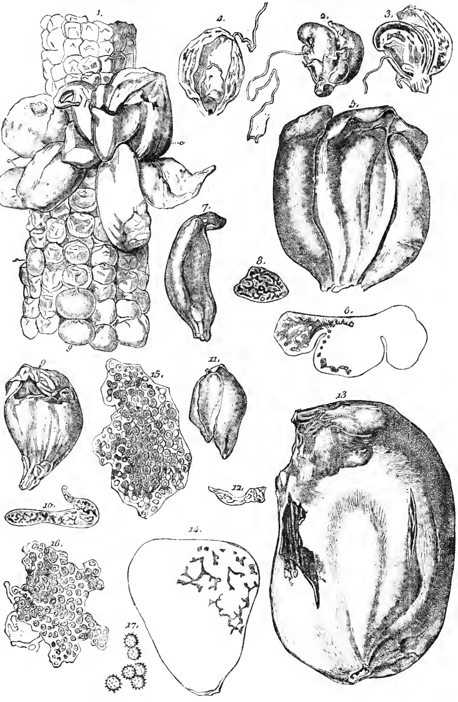
BLACK-SPOT OF ROSE AND ROSE PHRAGMIDIUM.

ROSE RUST.
Phragmidium mucronatum

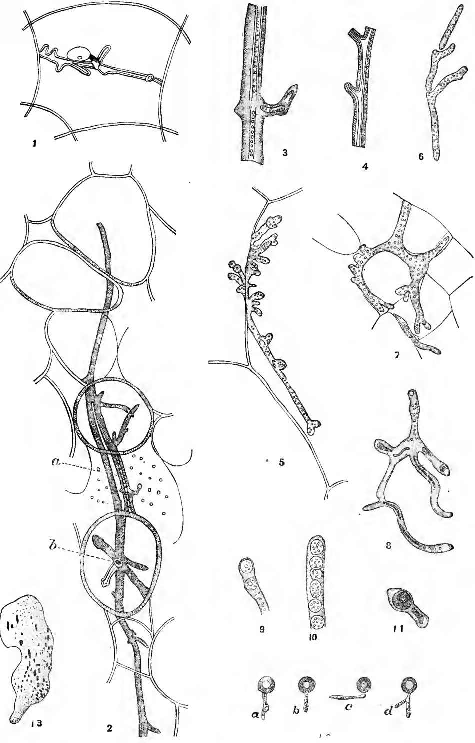


POWDERY MILDEW OF THE GOOSEBERRY.

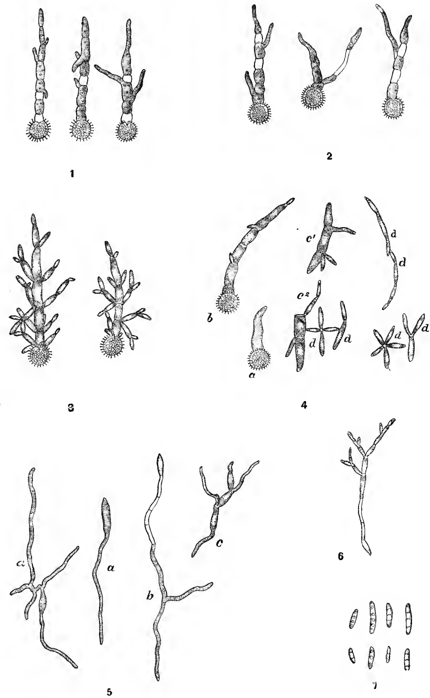
SMUT OF INDIAN CORN (USTILAGO ZEÆ-MAYS).
From photograph.



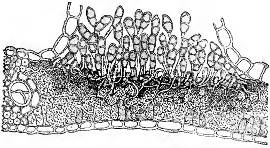
SMUT OF INDIAN CORN. (AFTER TULASNE.)



SMUT OF INDIAN CORN—MYCELIUM AND SPORE-FORMATION.



SMUT OF INDIAN CORN—GERMINATION OF SPORES IN WATER AND NUTRITIVE SOLUTIONS.
(AFTER BREFELD.)



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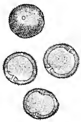

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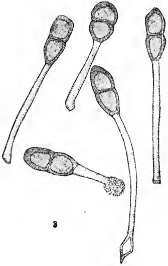

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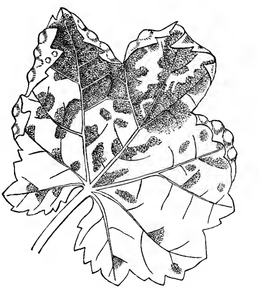
INDIAN CORN RUST.



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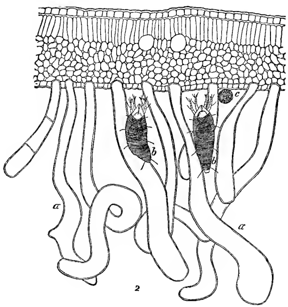

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ERINOSE.

REPORT OF THE ORNITHOLOGIST AND MAMMALOGIST.

SIR: I have the honor to submit herewith my second annual report upon the operations of the Division of Economic Ornithology and Mammalogy. It consists of two parts: (1) A statement of the work done during the year 1887; and (2) special reports embodying results of investigations.

STATEMENT OF WORK DONE.

The work of the division during the past year, as heretofore, has consisted chiefly in the collection of facts showing the relation of certain birds and mammals to agriculture, horticulture, and forestry; and in the preparation for publication of two important bulletins, namely, (1) on the English Sparrow, (2) on Bird Migration in the Mississippi Valley. In bringing together the necessary information two methods are employed, (*a*) the distribution of circulars of inquiry, and (*b*) work in the field and laboratory. The circulars of inquiry are distributed to a large number of farmers and persons known to be interested in birds throughout the country. The field work is carried on by members of the division staff and by special field agents employed for the purpose. These persons study the distribution and habits of the numerous species of known or supposed economic consequence, learning as much as possible about the food and breeding habits of each. Collections of stomachs are made for subsequent analysis, and much information is secured from farmers living in the neighborhood of the places visited. The results attained in this way are of the greatest value, because none but trained observers are employed. The field work is supplemented by laboratory work, which consists in the critical examination of the contents of stomachs, gizzards, and crops collected in the field. The elaboration of this material is a slow process, requiring much technical knowledge, as well as patience, on the part of the investigator. A single stomach sometimes contains representatives of several of the primary divisions of the animal kingdom. For instance, a Hawk's craw may hold at one time the remains of a meadow-mouse, a sparrow, a snake, a frog, a grasshopper, an earthworm, and a snail—representatives of the seven primary groups, mammalia, aves, reptilia, batrachia, arthropoda, vermes, and mollusca.

During the past year an assistant ornithologist, Dr. A. K. Fisher, has devoted most of his time to the study of the food material found in the stomachs of hawks and owls, of which the division has now upwards of six hundred. A brief statement of the contents of each stomach is made on a card prepared for the purpose, and these cards are arranged under species. A brief summary of the results of this investigation will be found in the present report.

The insect remains found in the various stomachs are submitted to Prof. C. V. Riley, Entomologist of the Department, for determination and report. A valuable report upon the insect food of the English Sparrow has been already received, and has been incorporated in the special bulletin on the English Sparrow (Bulletin No. 1 of the division).

The inquiry concerning the food habits of the Crow, the various Blackbirds or Grackles, and several other species of special economic importance, has resulted in the accumulation of so much information that special bulletins on these subjects will be published as soon as the material in hand can be properly arranged. The same is true of a number of species of Gophers and Mice, which have been found to exert marked effects upon agriculture or forestry.

A not unimportant incidental feature of the routine work of the division consists in the identification of specimens of birds and mammals sent to the Department for this purpose. The number of specimens thus sent reached several hundred during the past year and is constantly increasing. It is hardly necessary to add that great good is done by thus diffusing among the people an accurate knowledge of the birds and mammals with which they are surrounded.

Prof. Walter B. Barrows, assistant ornithologist, has been engaged in office work throughout nearly the entire year. He has been charged with the preparation for publication of the enormous mass of material in hand relating to the English Sparrow question. As stated in my annual report for 1886, circulars and schedules asking for information in regard to the English Sparrow were distributed by the division in 1885 and 1886. Replies were received from more than 3,000 persons. The information contained in these replies has been arranged for publication under seven different heads, as follows:

(1) Time and manner of first appearance of the English Sparrow; present abundance, and apparent rate of increase; kind and degree of assistance and protection afforded or withheld by man.

(2) Relation of the Sparrow to other birds.

(3) Injury to trees or vines.

(4) Injury to fruits and garden vegetables.

(5) Injury to grain.

(6) Relation of the Sparrow to injurious or other insects.

(7) Methods of restriction; suggestions for extermination; miscellaneous information.

The introductory portion of the Sparrow bulletin contains a synopsis of the principal facts brought to light by the investigation, together with deductions from the same, and suggestions to legislative bodies and to the people in regard to the best methods of abating the Sparrow scourge.

That the special bulletin on the English Sparrow question is one of general public interest, as well as importance, is shown by hundreds of applications for it that have been received at the Department in advance of its publication.

The bulletin on Bird Migration in the Mississippi Valley, by W. W. Cooke, was ordered to be printed in July, 1887, but has not yet been received from the Government Printer.

In addition to the office corps of the division, two persons have been employed as special field agents. Col. Alexander Macbeth, of Georgetown, S. C., has continued to serve the Department in collecting information relating to the Rice-bird problem, and Mr. Vernon

Bailey, of Elk River, Minn., has visited many parts of Minnesota, Dakota, and eastern Montana, for the purpose of studying the distribution and food habits of the various birds and mammals met with. This trip was particularly successful, and some of the results will be found in a special paper, forming a part of the present report. His report on birds treats of a very large number of species and is too bulky for publication in the Annual Report. His notes on the food of mammals and birds is an important contribution to economic zoology, and will be published as soon as supplemented by the results of the determination of the stomach contents collected by him. Much of Mr. Bailey's field work was done in the region where the eastern and western faunas meet or overlap, and the ranges of several species were determined with more precision than heretofore.

In connection with Colonel Macbeth's work in the rice-fields, a few experiments have been made with live Hawks for the purpose of frightening the birds from the fields. These experiments have been only partially successful, owing chiefly to the fact that the Department was unable to secure the services of an experienced falconer to train the Hawks and take charge of the experiments. One fact, however, was demonstrated, namely, that Rice-birds will not come near a live Hawk, even when resting on a stake; and when in motion, the Hawk is effective at much greater distances than when at rest. There can be no question that Hawks trained to fly about the fields would keep the Rice-birds off, and the expense would be less than that of the present system of "bird minding."

In addition to the investigations carried on by these special field agents, the assistant ornithologists, Prof. Walter B. Barrows and Dr. A. K. Fisher, made brief trips in order to obtain special information relating to subjects then under investigation. Professor Barrows visited the grape-growing district in central and western New York, and the results of his field work will be found in the special bulletin on the English Sparrow. Dr. Fisher visited northern Iowa, southern Minnesota, and southern Michigan, for the purpose of procuring information in regard to the depredations of Blackbirds and Gophers in the grain-fields of that area. Some of the results of his inquiry will be found in the present report.

A number of experiments in poisoning have been made by Dr. Fisher, for the purpose of ascertaining what poison or poisons may be used to best advantage in the destruction of certain pests.

The correspondence of the division continues to consume so large a portion of the time of the office force that it seriously interferes with the elaboration of material and the preparation of reports.

SPECIAL REPORTS.

The following special reports will be found herein:

(1) Food of Hawks and Owls. By Dr. A. K. Fisher, assistant ornithologist.

(2) Experiments in poisoning. By Dr. A. K. Fisher, assistant ornithologist.

(3) Some of the results of a trip through Minnesota and Dakota. By Vernon Bailey, special field agent.

(4) Notes on the depredations of Blackbirds and Gophers in Iowa and southern Minnesota. By Dr. A. K. Fisher, assistant ornithologist.

FOOD OF HAWKS AND OWLS.

By Dr. A. K. FISHER, *Assistant Ornithologist.*

The present brief synopsis of results, which is preliminary to a special report now in preparation on the food habits of the Hawks and Owls of the United States, is based on the examination of 1,072 stomachs, 651 of which are in the possession of the Department. Of the 421 stomachs not in the Department collection, the greater number were examined by Dr. B. H. Warren, State Ornithologist of Pennsylvania, and other members of the American Ornithologists' Union. The remainder were compiled from Prof. Samuel Aughey's "Notes on the Nature of the Food of the Birds of Nebraska"* and Mr. Edward Swift's recent article on "The Food of Rapacious Birds."†

Of the 1,072 stomachs examined, 89 were empty. Of the 983 containing food, 57 contained poultry; 20, game birds; 177, other birds; 528, mice; 137, other mammals; 51, reptiles and batrachians, and 255, insects. On looking at the following tables it will be seen that certain species feed principally on mice and insects, while others feed chiefly on poultry and small birds. In the latter category, fortunately, there are but 5 species in the Eastern States, namely, the Sharp-Shinned, Cooper's, Duck, and Pigeon Hawks, and the Great Horned Owl. Taking out the 126 stomachs of these five species, there remain 857 stomachs of 23 species, of which 31 contained poultry; 11, game birds; 109, other birds; 518, mice; 125, other mammals; 49, reptiles and batrachians, and 241, insects. In other words, poultry was found in but 3.6 per cent. of the 857 stomachs, while mice were found in 64.4 per cent.

In the accompanying tables the names of the animals found in the stomachs are given in general terms, such as *mouse, mole, shrew.* In nearly all cases (more than 99 per cent.) the exact species of each has been determined and recorded, and will be given in the final report. This is important, inasmuch as allied species often differ in economic consequence. Some small mammals are beneficial, and the injurious species are harmful in different degrees, according to their food habits and the character of the places which they inhabit.

The following persons have contributed stomachs of hawks and owls to the Department collection; Dr. W. C. Avery, Vernon Bailey, W. B. Barrows, F. M. Chapman, Hubert L. Clark, William Couper, F. T. Cuthbert, E. O. Damon, L. M. Davies, J. L. Davison, F. J. Dixon, William F. Doertenbach, William Dutcher, Jonathan Dwight, jr., Dr. A. K. Fisher, W. K. Fisher, M. M. Green, C. C. Hanmer, E. M. Hasbrouck, A. H. Hawley, J. H. Hendrickson, W. F. Hendrickson, H. W. Henshaw, H. K. James, C. A. Keeler, William G. W. Leizear, J. B. Lewis, William Lloyd, F. A. Lucus, Dr. C. Hart Merriam, G. S. Miller, jr., H. H. Miller, J. Percy Moore, F. S. Place, Charles W. Richmond, Robert Ridgway, C. B. Riker, John H. Sage, W. E. Saunders, J. M. Shaffer, Dr. Hugh M. Smith, R. W. Smith, F. Stephens, Willard E. Treat, Dr. B. H. Warren, F. S. Webster, H. G. White, Otto Widmann, A. H. Wood.

*First Annual Report of United States Entomological Commission, Appendix, pp. 42–46, 1878.

†Forest and Stream, Vol. XXX, No. 6, March 1, 1888, p. 104.

Statement of the stomach contents of more than 1,000 Hawks and Owls.

[In Dr. Warren's specimens, the cross (+) indicates that the stomach contained food of the character specified in the column-heading under which it occurs, but that its specific identity was not determined.]

SWALLOW-TAILED KITE (*Elanoides forficatus*).

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Hawkinsville, Fla	Mar. 31, 1885				Lizard; tree-toad; grasshoppers; beetles.
Do	...do				Lizard; grasshoppers; beetles.
Dixon County, Nebr	June, 1865				60 locusts, 5 other insect.
Do	...do				69 locusts, 3 other insect.
Sarpy County, Nebr	Sept., 1873				75 insects.

Summary.—Of 5 stomachs examined 5 contained insects; 2, lizards; 1, tree-toad.

MISSISSIPPI KITE (*Ictinea mississippiensis*).

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Madisonville, La	May 29, 1886				Fragments.
Do	May 30, 1886				Beetles.

Summary.—Of the 2 stomachs examined, both contained insects.

MARSH HAWK (*Circus hudsonius*).

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Amityville, L. I., N. Y	Oct. 17, 1885			Meadow mouse.	
Washington, D. C	Oct. 29, 1886			3 meadow mice.	
Bergen County, N. J	Nov. 26, 1885			Meadow mouse.	
Washington, D. C	Jan., 1887			...do	
Sandy Spring, Md	Feb. 11, 1887		Junco		
Do	Oct. 2, 1887			Meadow mouse.	
Do	Oct. 14, 1887			...do	
Do	Nov. 17, 1887			2 pine mice; 2 meadow mice.	
Do	Nov. 18, 1887		Tree sparrow	Pine mouse; 2 meadow mice.	
Do	Nov. 23, 1887			Meadow mouse.	
Travare, Dak	July 5, 1887			2 striped gophers.	
Pembina, Dak	July 30, 1887			Striped gopher	
Do	...do			Hair of striped gopher.	
Do	...do			Striped gopher	
Oakdale, N. Y	Oct. 4, 1887			Shrew	
Long Island City, N. Y	Oct. 18, 1887			2 meadow mice.	
East Hartford, Conn	Sept. 17, 1887	Duck			
Cromwell, Conn	Oct. 5, 1886			Meadow mouse.	
Devil's Lake, Dak	Aug. 11, 1887			Striped gopher.	
Do	Aug. 17, 1887			Meadow mouse.	
Sandy Spring, Md	Oct. 17, 1887			...do	
Do	Feb. 13, 1887				Empty.
Sing Sing, N. Y	Oct. 1, 1881	Fowl			
Do	Sept. 17, 1882		Small bird		
Wethersfield, Conn	Sept. 17, 1887			Mice	
Do	Sept. 24, 1887		Small bird	...do	
East Hartford, Conn	Nov. 12, 1886			3 meadow mice.	
Do	Oct. 17, 1886			2 meadow mice.	
Paint Rock, Tex	Dec. 7, 1886			Skunk	
Washington, D. C	Sept. 11, 1886	Fowl			
East Bradford, Pa	Aug. 22, 1878			Mice	
Westtown, Pa	Aug. 30, 1878		2 warblers	...do	
Oxford, Pa	Nov. 5, 1879			...do	
Brazile Creek, Nebr	Oct., 1869				Reptiles; 60 insects.
Do	...do				15 locusts; 77 other insects.
Otoe County, Nebr	Sept., 1864				71 locusts, 10 other insects.
Sarpy County, Nebr	...do				Lizard; 69 locusts.
Do	...do			Gopher	51 locusts.
Douglas County, Nebr	Oct., 1864				Lizards; 43 locusts.

Statement of the stomach contents of more than 1,000 *Hawks and Owls*—Continued.

MARSH HAWK (*Circus hudsonius*)—Continued.

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Elmira, N. Y	May 7, 1886			4 mice	
Do	July 11, 1886			Mouse	Beetles.
Tyrone, N. Y	Aug. 17, 1886			Red squirrel	
Do	....do			Field mice	
Barton, N. Y	Aug. 1, 1886	Woodcock.			Beetles.
Hale County, Ala	Mar. 17, 1888	Quail			
Washington, D. C	Mar. 28, 1888			Meadow mouse.	

Summary.—Of 46 stomachs examined 5 contained poultry or game birds; 5, other birds; 24, mice; 9, other mammals; 3, reptiles; 8, insects; and 1 was empty. Twenty-two stomachs examined by the division contained 21 mice.

SHARP-SHINNED HAWK (*Accipiter velox*).

Sing Sing, N. Y	Sept. 10, 1885				Empty.
Do	Sept. 17, 1885		2 warblers		
Do	....do		Warbler		
Do	Sept. 24, 1885		Field sparrow		
Southold, N. Y	Nov. 20, 1885		Chippie, purple grackle.		
Alfred Centre, N. Y	Sept. 17, 1885		Warbler		
Taunton, Mass	Oct. 6, 1885		Goldfinch		
Do	Nov. 21, 1885		2 small birds		
Sing Sing, N. Y	Sept. 25, 1886		Junco and kinglet.		
Peterborough, N. Y	July 22, 1886		Small bird		
Portland, Conn	Mar. 27, 1886		Robin		
Maplewood, N. J	May 25, 1886		Oriole; swift		
Montgomery Co., Pa	Sept. 18, 1886		Small bird		
Woodstock, Conn	May 2, 1887		....do		
Long Island City, N. Y	Sept. 21, 1887		English sparrow; warbler.		
Greensborough, Ala	Nov. 11, 1887		White-throated sparrow.		
Middletown, Conn	Jan. 19, 1887		2 English sparrows.		
Portland, Conn	Apr. 2, 1887		Robin		
Do	Oct. 20, 1887		Field sparrow		
Fort Buford, Dak	Sept. 9, 1887		Thrush		
Washington, D. C	Dec. 31, 1887		White-throated sparrow.		
Sing Sing, N. Y	Apr. 7, 1880		Robin		
East Hartford, Conn	Oct. 17, 1886		Warbler		
Easthampton, Mass	May 9, 1874		Junco		
South Windsor, Conn	Nov. 4, 1887				
Portland, Conn	Nov. 8, 1886				Do.
Do	Feb. 4, 1881		Goldfinch		Do.
Fort Buford, Dak	Sept., 1887		Dove		
Sandy Spring, Md	Apr. 23, 1887				
Do	....do				Do.
Do	....do		Bluebird		Do.
Do	Sept. 20, 1887				
Do	Sept. 26, 1887		Small bird		Do.
Do	Oct. 2, 1887				
Do	Nov. 5, 1887				Do.
Do	Nov. 22, 1887				Do.
Chester County, Pa	Nov. 26, 1886		Fox sparrow; song sparrow.		Do.
Do	Sept. 20, 1884		Field sparrow		Beetles.
Do	Sept. 28, 1880	Quail			
Do	Sept. 10, 1874		English sparrow	Mice	
Do	Oct., 1875		+	....do	
Do	Feb. 16, 1880			...do	
Do	May 19, 1881	Poultry.			Insects.
Elmira, N. Y	Mar. 4, 1886		English sparrow	Mouse	
Do	Apr. 18, 1886		Small bird		
Big Flats, N. Y	Sept. 23, 1886		English sparrow		
Do	....do				Indeterminate.
Gainesville, Fla	Dec. 22, 1887				Empty.

Summary.—Of 48 stomachs examined, 2 contained poultry and game bird; 35, other birds; 4, mice; 2, insects; and 10 were empty. Total number of small birds, 41.

Statement of the stomach contents of more than 1,000 *Hawks and Owls*—Continued.

COOPER'S HAWK (*Accipiter cooperi*).

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Taunton, Mass	Sept. 21, 1885		Chewink		
Do	Oct. 6, 1885		do		1 grasshopper.
River Vale, N. J	Sept. 18, 1 86				
Washington, D. C	Nov. 28, 1886		Tree sparrow		
Sing Sing, N. Y	Sept. 7, 1880	Chicken			
Do	Nov. 18, 1884	do			
Greensborough, Ala	Oct. 28, 1887				Empty.
Do	Mar. 6, 1887	Pigeon			
Do	July, 1887	do			
Do	Aug. 4, 1887	do			Do.
Do	Aug. 30, 1887				
Do	Sept. 13, 1887	Pigeon			Sand lizard.
Do	Sept. 27, 1887				Empty.
Wethersfield, Conn	Sept. 9, 1887				Do.
East Hartford, Conn	July 31, 1887				Empty.
Sandy Spring, Md	Jan. 14, 1887	Quail			
Do	Mar. 1, 1887		Song sparrow		
Do	Apr. 22, 1887	Chicken			
Do	May 7, 1887	do			Do.
Do	May 25, 1887				Do.
Do	Sept. 14, 1887				Do.
Do	Sept. 21, 1887				
Do	Nov. 24, 1887		Purple grackle		
Do	Dec. 26, 1887	Quail			
Do	Jan. 30, 1888	do			
Do	Feb. 11, 1888		Junco; savanna sparrow.		
Chester County, Pa	Nov. 13, 1886		Junco		
Do	Nov. 27, 1886		Small bird		
Do	Dec. 17, 1886	Chicken			
Do	Jan. 10, 1887		Small bird		
Do	Jan. 17, 1887				Do.
Do	Feb. 1, 1887		Small bird		
Do	Feb. 20, 1887	Chicken			
Do	Mar. 3, 1887		Meadow lark		
Do	Dec. 6, 1878		+		
New Castle Co., Del	Nov. 1, 1878	Poultry			
Williston, Pa	Dec. 6, 1878		+		
East Bradford, Pa	May 25, 1875				Frog.
East Goshen, Pa	May 20, 1877			Mice	Coleoptera.
West Chester, Pa	Aug. 25, 1876		English sparrow		
Pocopson, Pa	Nov. 12, 1879	Poultry			
West Chester, Pa	Sept. 10, 1880		English sparrow		
Sandy Spring, Md	Mar. 17, 1888		Sparrow		
Gainesville, Fla	Dec. 22, 1887				Empty.
Sandy Spring, Md	Mar. 24, 1888		Song sparrow		
Do	Apr. 2, 1888				Do.

Summary.—Of 46 stomachs examined, 15 contained poultry or game birds; 17, other birds; 1, mice; 1, frog; 1, lizard; 2, insects; and 11 were empty.

GOSHAWK (*Accipiter atricapillus*).

Sandy Spring, Md	Dec. 27, 1887			Rabbit	
Adirondack, N. Y	Oct. 31, 1882			2 red squirrels	
Philadelphia, Pa	Jan. 12, 1886			Rabbit	
Dixon and Cedar Counties, Nebr.	Aug., 1867			do	Few locusts.
Tioga, Pa	Feb. 17, 1886			Mouse; weasel	
Elmira, N. Y	Apr. 12, 1886			Mice	Beetles.

Summary.—Of 6 stomachs examined, 2 contained mice; 5, other mammals; 2, insects.

RED-TAILED HAWK (*Buteo borealis*).

Taunton, Mass	Nov. 18, 1885		Feathers		
Portland, Conn	Sept. 4, 1885				2 adders; ribbon snake; toad.
Do	Nov. 25, 1885	Fowl			
Alfred Centre, N. Y	Aug. 28, 1886				Grasshoppers.
Do	Oct. 25, 1886			Shrew	

Statement of the stomach contents of more than 1,000 *Hawks and Owls*—Continued.

RED-TAILED HAWK (*Buteo borealis*)—Continued.

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Peterborough, N. Y	July 5, 1886	Fowl			
Oneida Lake, N. Y	Aug. 30, 1886			Red squirrel	
Morrisville, N. Y	Sept. 27, 1886			Meadow mouse	
Chester County, Pa	May 15, 1886	Fowl	Oriole	Rabbit	Grubs.
Do	Mar. 10, 1886			Meadow mouse	
Birmingham, Pa	Mar. 15, 1886	Fowl	Grackle		
Portland, Conn	July 25, 1886				Empty.
Chickamauga, Tenn	Feb. 13, 1886				Offal.
Lockport, N. Y	July 13, 1886			4 meadow mice	Toad; 2 beetles.
Forge, Suffolk County, N. Y.	Feb. 16, 1887	Fowl			
Whitewater, Wis	Aug. 17, 1887			Meadow mouse	13 grasshoppers; 5 crickets; 1 beetle; 1 Crawfish.
Washington, D. C	May 4, 1887			Pine mouse; meadow mouse.	Large adder.
Middletown, Conn	Nov. 20, 1886			Mouse	5 grasshoppers.
Portland, Conn	Dec. 29, 1886			Gray squirrel	
Gainesville, Va	Jan. 2, 1888			2 house mice	
Howard County, Md	Nov. 3, 1887				Empty.
Washington, D. C	Dec. 29, 1887		Song sparrow	Meadow mouse.	
Do	Jan. 20, 1888			House mouse; 3 meadow mice.	
Sing Sing, N. Y	Feb. 18, 1885			4 meadow mice; 2 white-footed mice; shrew.	
Do	Apr. 13, 1885			2 shrews	
Lewis County, N. Y	Aug. 3, 1876				Garter snake.
Portland, Conn	Mar. 2, 1887				Empty.
Troy, Pa			Screech owl		
Devil's Lake, Dak	Aug. 11, 1887			Gray gopher; striped gopher.	Frogs; 10 large grass-hoppers.
East Hartford, Conn	Sept. 14, 1885				2 frogs; potato beetle.
Sandy Spring, Md	Jan. 8, 1887			Pine mouse; shrew.	
Do	do			2 meadow mice	
Do	do			Meadow mouse; white-footed mouse; shrew.	
Do	do			4 house mice; 1 meadow mouse.	
Do	do			3 house mice; 1 meadow mouse; shrew.	
Do	do			3 meadow mice.	
Do	do			3 meadow mice; 3 shrews.	
Do	do			1 house mouse; 2 pine mice; 2 meadow mice; 1 shrew.	
Do	Jan. 14, 1887				Empty.
Do	do			1 pine mouse; 2 meadow mice.	
Do	Jan. 22, 1887			Meadow mouse.	
Do	do			do	
Do	do			do	
Do	Jan. 28, 1887			do	
Do	do		Crow	do	
Do	do		do		
Do	Feb. 11, 1887				Do.
Do	do			Meadow mouse	Larva.
Do	do			Pine mouse; meadow mouse.	
Do	Mar. 2, 1887			Shrew	
Do	do				Do.
Do	do			Meadow mouse; 2 house mice.	
Do	do			1 meadow mouse; 1 house mouse.	
Do	do			2 meadow mice; gray squirrel.	
Do	do			Meadow mouse.	
Do	do			Shrew	

Statement of the stomach contents of more than 1,000 *Hawks and Owls*—Continued.

RED-TAILED HAWK (*Buteo borealis*)—Continued.

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Sandy Spring, Md	Mar. 2, 1887				Empty.
Do	....do	Fowl			
Do	....do			5 meadow mice.	
Do	....do		Bluebird	Meadow mouse.	
Do	....do		Tree sparrow		Grasshopper.
Do	....do			Meadow mouse.	
Do	....do			....do	
Do	Mar. 5, 1887		2 song sparrows	....do	
Do	....do			Meadow mouse; white-footed mouse; mole.	
Do	....do		Song sparrow	Rabbit	
Do	....do		Feathers		
Do	....do				Empty.
Do	....do			2 meadow mice; rabbit.	
Do	Mar. 8-10, '87			Meadow mouse.	2 wood frogs.
Do	....do			....do	
Do	....do				Empty.
Do	....do			3 meadow mice.	
Do	....do			2 moles	
Do	....do			Shrew	
Do	....do			Rabbit	
Do	....do			....do	
Do	....do			Gray squirrel	
Do	....do			Meadow mouse; chipmunk.	Crawfish.
Do	Mar. 12, 1887		Feathers		
Do	Mar. 18, 1887		Robin	Meadow mouse.	
Do	Mar. 24, 1887			3 meadow mice.	
Do	Apr. 1, 1887		2 sparrows	Meadow mice	
Do	....do			Pine mouse	
Do	Apr. 25, 1887			Mole	Insect remains.
Do	Apr. 28, 1887			Meadow mouse; gray squirrel.	
Do	Nov. 14, 1887				Empty.
Do	....do				Do.
Do	....do				Do.
Do	Nov. 27, 1887			Gray squirrel	
Do	Dec. 12, 1887				Do.
Do	....do			House mouse	
Do	Dec. 24, 1887			2 meadow mice.	
Do	Dec. 26, 1887				Do.
Do	....do			1 house mouse; 1 meadow mouse; 3 shrews.	
Do	....do			Meadow mouse.	
Do	....do				Do.
Do	Jan. 3, 1888			2 meadow mice.	
Do	Jan. 7, 1888			Meadow mouse.	
Do	Jan. 14, 1888		Meadow lark	3 meadow mice.	
Do	Jan. 11, 1888			2 house mice	
Do	Jan. 14, 1888	Fowl			
Do	Jan. 19, 1888			5 meadow mice.	
Do	Jan. 30, 1888		Crow		
Do	Jan. 28, 1888			Meadow mouse.	
Do	Jan. 30, 1888		Crow	House mouse	
Do	Feb. 13, 1888				Do.
Do	Feb. 18, 1888				Do.
Do	Feb. 22, 1888				Do.
Chester County, Pa	May, 1886	Fowl	Oriole	Gray squirrel	
Do	Oct. 15, 1886			House mouse	
Do	Nov. 22, 1886			Meadow mouse.	
Do	Nov. 16, 1886	Fowl		....do	
Do	Dec. 4, 1886				Do.
Do	Dec. 8, 1886				Offal.
Do	Dec. 29, 1886			4 meadow mice.	
Do	Feb. 11, 1887				Empty.
Do	Feb. 16, 1887				Do.
Do	Dec. 11, 1886		Sparrow		
Do	Jan., 1887	Fowl		Meadow mouse.	
Do	Dec. 11, 1886				Do.
Do	Dec., 1886			House mouse; meadow mouse.	
Do	....do		Song sparrow	2 meadow mice.	
Do	Nov., 1886		....do	Pine mouse	
Do	....do			....do	
Do	Feb. 16, 1887	Fowl			
Do	Dec., 1886	do.		Meadow mouse; 2 house mice.	

Statement of the stomach contents of more than 1,000 *Hawks and Owls*—Continued.

RED-TAILED HAWK (*Buteo borealis*)—Continued.

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Chester County, Pa	Dec. 11, 1886			7 house mice	
Do	Dec. 18, 1886				Empty.
Do	Apr. 20, 1886			Mouse	Beetles.
Do	Dec. 28, 1886			4 meadow mice.	
Do	Nov., 1886				Empty.
Do	...do			Meadow mouse.	
Do	...do			2 meadow mice.	
Do	...do			3 meadow mice.	
Do	...do			2 meadow mice.	
Do	Dec. 28, 1886			1 meadow mouse	
Do	...do			Meadow mice; rabbit.	
Do	...do			5 meadow mice.	
Do	Jan. 15, 1887	Fowl			
Do	Nov., 1886			2 house mice; 1 meadow mouse	
Do	...do			3 meadow mice.	
Do	Jan., 1887			2 meadow mice; mole.	
Do	...do			Meadow mouse; rabbit; shrew.	
Do	...do			Meadow mouse; red squirrel.	
Do	...do			3 meadow mice.	
Do	Oct., 1886			3 meadow mice; red squirrel.	
Do	Dec., 1886			4 meadow mice.	
Do	...do			1 meadow mouse	
Do	Jan., 1887		Feathers	...do	
Do	...do			Rabbit	
Do	...do		Feathers		
Do	Dec., 1886			3 meadow mice.	
Do	Oct., 1886			Red squirrel	
Do	Dec., 1886	Fowl		House mouse	Grasshopper.
Do	...do	...do			
Do	Jan. 25, 1887			House mouse	
Do	...do			Meadow mouse; white-footed mouse.	
Do	Jan. 26, 1887			Meadow mouse.	
Do	...do			6 meadow mice.	
Do	Dec. 31, 1886			Mouse	
Do	Jan. 1, 1887			White-footed mouse; shrew.	
Do	Jan. 3, 1887			Meadow mouse.	
Do	Jan. 7, 1887			Mouse	
Do	Jan., 1887			Meadow mouse.	
Do	...do			2 meadow mice.	Frog.
Do	...do			2 meadow mice; shrew.	
Do	...do			1 meadow mouse	
Do	...do			Meadow mouse.	
Do	...do			...do	
Do	...do			...do	
Do	Jan. 18, 1887		Meadowlark		
Do	Jan. 17, 1887			House mouse	
Do	Jan. 22, 1887			5 meadow mice.	
Do	Nov., 1886			Mouse	
Do	Dec., 1886			Red squirrel	
Do	Nov., 1886			Meadow mouse; red squirrel.	
Do	...do			Meadow mouse.	
Do	Jan., 1887		Tree sparrow		
Do	...do				Empty.
Do	...do		Crow		
Do	...do			Meadow mouse.	
Do	...do			2 meadow mice; white-footed mouse.	
Do	Feb., 1887			Meadow mouse.	
Do	...do			...do	
Do	...do			6 meadow mice.	
Do	...do			Meadow mouse; shrew.	
Do	...do			3 meadow mice; 2 house mice.	
Do	...do				Offal.
Do	Mar. 10, 1887			Shrew	
Do	...do			Meadow mouse.	
Do	...do			2 meadow mice.	

Statement of the stomach contents of more than 1,000 *Hawks and Owls*—Continued.

RED-TAILED HAWK (*Buteo borealis*)—Continued.

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Chester County, Pa	Feb., 1887			7 meadow mice.	
East Bradford, Pa	Feb. 4, 1879			Mice	
Westtown, Pa	Jan. 5, 1881				Grasshoppers.
East Bradford, Pa	Feb. 15, 1879			Mice	
Do	...do			...do	
Do	...do			...do	
Williamstown, Pa	Apr. 4, 1878			...do	
Westtown, Pa	Mar. 11, 1879			...do	
Pocopson, Pa	Nov. 25, 1878	Quail			
Willistown, Pa	Jan. 3, 1879			Mice	
West Bradford, Pa	Jan. 13, 1879	Poultry			
Kennert, Pa	Jan. 15, 1879	..do			
Do	...do			Mice	
Willistown, Pa	Jan. 21, 1879			...do	
Do	...do			...do	Insects.
East Bradford, Pa	Mar. 24, 1879			...do	Do.
Do	Dec. 25, 1884			...do	
Chester County, Pa	Feb. 15, 1878			...do	
Birmingham, Pa	Dec. 31, 1884	Poultry			
Willistown, Pa	Jan. 6, 1885			Mice	
Do	...do			...do	
East Bradford, Pa	...do			...do	
Chester County, Pa	Jan. 5, 1881				Grasshoppers.
Willistown, Pa	Feb. 15, 1878			Mice	
Do	Oct., 1876		+	Rabbit	
East Bradford, Pa	Aug. 15, 1876		+		
Willistown, Pa	Apr. 8, 1877	Poultry		Mice	
Do	...do	..do			
Lancaster County, Pa	Apr. 2, 1878			Mice	
West Bradford, Pa	Nov. 25, 1879	Quail			
East Bradford, Pa	Feb. 4, 1879			Mice	
Caln, Pa	Feb. 22, 1879			...do	
Do	...do			...do	
Westtown, Pa	Jan. 23, 1879			...do	
Do	...do			...do	
East Bradford, Pa	Jan. 20, 1879			...do	
Westtown, Pa	Jan. 28, 1879			...do	
Do	...do			...do	
Do	Jan. 20, 1879			...do	
Do	do			...do	
East Bradford, Pa	Feb., 1879			...do	
Do	...do			...do	
Lancaster County, Pa	Apr. 2, 1878			...do	
East Bradford, Pa	Feb., 1879			...do	
Westtown, Pa	Jan. 28, 1879			...do	
Chester County, Pa	...do				Offal.
Pocopson, Pa	Feb. 8, 1879			Mice	
Caln, Pa	Feb. 9, 1879			...do	
West Goshen, Pa	Feb. 7, 1879			...do	
Westtown, Pa	Jan. 29, 1879			...do	
Maryland	Feb., 1879			Red squirrel; mice.	
East Bradford, Pa	Feb. 8, 1879			Mice	
Willistown, Pa	Jan. 21, 1879			...do	
West Whiteland, Pa	Mar., 1879			3 mice	
Willistown, Pa	Jan. 13, 1879			Mice	
Chester County, Pa	Jan. 3, 1879	Poultry			
West Bradford, Pa	Jan. 3, 1880	..do			
Willistown, Pa	Nov. 27, 1874			Red squirrel	
East Bradford, Pa	Dec., 1882			Red squirrel; mice.	
Willistown, Pa	Jan., 1882			Rabbit	
Westtown, Pa	Jan. 5, 1881			Mice	Grasshoppers and crickets.
Willistown, Pa	Jan. 2, 1880			...do	Insects.
West Bradford, Pa	Nov. 27, 1880			...do	
Willistown, Pa	Mar. 27, 1880		+	...do	
Do	Mar. 22, 1880	Quail			
East Goshen, Pa	Mar. 20, 1880			Red squirrel; mice.	
Willistown, Pa	...do			Mice	
Birmingham, Pa	Feb. 26, 1880			...do	
Delaware County, Pa	Feb. 23, 1880			...do	
Do	... do			...do	
Do	Jan. 30, 1880			...do	
Westtown, Pa	Dec. 5, 1879			...do	
Chester County, Pa	Dec. 3, 1879	Poultry			
Do	...do			Mice	
New Garden, Pa	Nov. 26, 1879			...do	
East Goshen, Pa	Sept. 15,			... do	

Statement of the stomach contents of more than 1,000 *Hawks and Owls*—Continued.

RED-TAILED HAWK (*Buteo borealis*)—Continued.

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Chester County, Pa	Dec. 10, 1877	Poultry			
Do	Oct. 3, 1880			Mice	
Willistown, Pa	Feb., 1876		Feathers		
Do	Jan. 20, 1876			Mice	
Do	Jan., 1876			do	
Do	Dec. 19, 1878			do	
Do	Jan. 18, 1875			do	
Do	Nov. 20, 1876			do	
Do	Mar. 26, 1876			do	
Chester County, Pa	Sept., 1874			Gray squirrel	
West Goshen, Pa	Dec., 1875			Mice	
East Goshen, Pa	Feb. 19, 1875				Empty.
Dakota City, Nebr	July, 1870	Quail			37 insects
Elmira, N. Y	June 1, 1886			Rat; red squirrel	
Do	June 19, 1886	Chicken			
Do	July 21, 1886				Grasshopper; beetles.
Do	Oct. 2, 1886			3 mice	
Wellsburgh, N. Y	Apr. 7, 1887			Hair	Beetles
Halsey Valley, N. Y	Aug. 10, 1887			2 mice	Grasshoppers
Sandy Spring, Md	Mar. 6, 1888		Tree sparrow		
Do	do		2 tree sparrows; 1 song sparrow.	Meadow mouse.	
Do	Mar. 7, 1888				Empty.
Do	do				Do.
Do	do		Song sparrow; junco.	Meadow mouse; rabbit.	
Do	Mar. 9, 1888			Mole	
Do	Mar. 15, 1888				Do.
Do	do		Song sparrow	Meadow mouse.	
Do	do			2 house mice	
Do	Mar. 17, 1888			Shrew	
Do	do			Meadow mouse.	
Do	Mar. 19, 1888			do	
Gainesville, Fla	Jan. 4, 1888			2 cotton rats	
Sandy Spring, Md	Mar. 24, 1888			1 pine mouse; 1 meadow mouse	
Chester County, Pa	Feb., 1887			2 meadow mice.	
Do	Jan., 1887			do	
Do	Apr., 1887			3 meadow mice.	
Do	Feb., 1887			Meadow mice	
Do	do			do	
Do	do			do	
Do	do			do	
Sandy Spring, Md	Mar. 28, 1888				Toad; crawfish.
Do	Mar. 30, 1888			2 meadow mice.	May beetle; other insects.
Do	Apr. 18, 1888				Empty.

Summary.—Of 311 stomachs examined, 29 contained poultry or game birds; 35, other birds; 203, mice; 55, other mammals; 9, batrachians or reptiles; 24, insects; 3, crawfish; 4, offal: and 39 were empty. Two hundred and ten examined by the division contained 270 mice.

RED-SHOULDERED HAWK (*Buteo lineatus*).

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Sing Sing, N. Y	Oct. 3, 1885		Flicker		Toad; snake; cricket; larva.
Alfred Centre, N. Y	Sept. 11, 1885			Mouse	Grasshopper; larva; spider.
Do	Sept. 13, 1886			4 shrews	Grasshoppers; spider.
Do	Sept. 12, 1886				Grasshoppers.
Peterborough, N. Y	June 25, 1886				Frogs; beetles.
Do	do			Red-backed mouse; 3 shrews.	
Do	June 28, 1886			Meadow mouse; 3 shrews.	Beetles; crawfish; spider.
Do	do			1 shrew	
Do	July 28, 1886				Insects
Oneida Lake, N. Y	Aug. 30, 1886				Squash bug
Morrisville, N. Y	Sept. 6, 1886			Meadow mouse; 1 shrew.	10 grasshoppers
Birmingham, Pa	Mar. 15, 1886		Feathers		

Statement of the stomach contents of more than 1,000 *Hawks and Owls*—Continued.

RED-SHOULDERED HAWK (*Buteo lineatus*)—Continued.

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Chester County, Pa	Jan. 3, 1886				Cricket; larva; 2 spiders.
East Hartford, Conn	Dec. 14, 1886			Meadow mouse.	Frog.
Gainesville, Fla	Feb. 28, 1887				Do.
Do	Mar. 17, 1887				Frog; dragon flies.
Do	Apr. 7, 1887				Lizard; 2 crickets; larva of beetles.
Do	Apr. 11, 1887				Snake; insects; earth worm.
Greensborough, Ala	Nov. 19, 1887				Grasshopper; crickets.
East Hartford, Conn	Apr. 5, 1887			Shrew	Garter snake; bull-frog.
Do	July 5, 1887			Meadow mouse.	Beetle; wasp; larva.
Portland, Conn	Oct. 29, 1887				Leopard frog.
Washington, D. C	Dec. 24, 1887			House mouse; 2 meadow mice.	Crawfish.
Do	...do			Meadow mouse; shrew.	Frog; grasshoppers.
Do	Jan. 22, 1888				Empty.
Greensborough, Ala	Feb. 16, 1888				Grasshoppers; beetles.
Locust Grove, N. Y	Aug. 24, 1876				Grasshoppers.
Sing Sing, N. Y	Apr. 8, 1880			Mouse	
Do	May 6, 1880			Meadow mouse; shrew.	2 toads; grasshopper.
Do	Sept. 19, 1882				Toad; larvæ.
Do	Feb. 2, 1884			2 shrews	Frog; salamander.
Do	Feb. 14, 1885			Mole	
Do	Apr. 2, 1885			Meadow mouse; shrew.	
Portland, Conn	Oct. 18, 1886			Mice	
East Hartford, Conn	Oct. 29, 1886			Mole	
Sandy Spring, Md	Jan. 8, 1887			House mouse	
Do	...do			2 house mice; white-footed mouse; 1 meadow mouse.	
Do	Jan. 28, 1887			4 meadow mice.	
Do	Feb. 11, 1887			Pine mouse; meadow mouse; shrew.	Tree-frog; beetle; spider.
Do	Mar. 8, 1887			House mouse	
Do	...do			Mouse	
Do	...do			2 meadow mice.	
Do	Mar. 24, 1887		Screech-owl	Meadow mouse.	
Do	Nov. 26, 1887				Grasshoppers; beetles; spider.
Do	Dec. 3, 1887			Meadow mouse.	Grasshopper.
Do	...do			Pine mouse	
Do	Dec. 9, 1887			Meadow mouse.	
Do	Dec. 27, 1887			4 meadow mice.	
Do	Jan. 30, 1888			1 mole	
Do	...do		Field sparrow		
Do	...do		Carolina dove	Meadow mouse.	
Chester County Pa	Nov. 23, 1886			2 meadow mice.	Grasshopper.
Do	Jan. 20, 1886				Insects.
Do	Apr. 3, 1886			Opossum	Crickets; larvæ.
Do	Nov. 29, 1886			Mouse	
Do	Dec. 1, 1886			Meadow mouse.	
Do	Dec. 2, 1886			...do	
Do	Dec. 15, 1886			Shrew	
Do	Dec. 16, 1886			Meadow mouse.	
Do	Jan. 21, 1886			5 meadow mice.	
Do	Jan. 26, 1887			...do	
Do	Jan. 28, 1887			Mouse	
Do	Jan., 1887			...do	
Do	...do			...do	
Do	Dec. 18, 1886			Meadow mouse; rabbit.	
Do	Dec. 20, 1886			Meadow mouse.	Larva; offal
Do	Jan. 18, 1887			...do	
Do	...do				Empty.
Do	Jan., 1887			Meadow mouse.	
Do	Feb., 18 7			3 meadow mice.	

Statement of the stomach contents of more than 1,000 *Hawks and Owls*—Continued.

RED-SHOULDERED HAWK (*Buteo lineatus*)—Continued.

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Willistown, Pa	Feb. 20, 1881			Mice	
Do	Mar. 3, 1881			Rabbit	
Pennsylvania	Dec. 25, 1879			Mice	Grasshoppers.
West Chester, Pa	Dec. 9, 1879			...do	Do.
West Pikeland, Pa	...do				Do.
Westtown, Pa	Feb. 4, 1878			+	Do.
Do	Feb. 4, 1879			+	Do.
Willistown, Pa	Jan 21, 1879				Empty.
Volusia County, Fla	Mar. 18, 1886				Catfish.
Saint John's River, Fla	Mar. 14, 1886			+	Insects.
Milltown, Pa	Dec. 29, 1884			Mice	
Thornburgh, Pa	Jan. 8, 1885			...do	Do.
Westtown, Pa	Jan. 10, 1879			...do	
Do	Jan. 28, 1879			...do	
Do	Feb. 20, 1879			...do	
Do	Jan. 27, 1879			...do	Do.
Do	Feb. 4, 1879			...do	
Do	Feb., 1879			...do	
Do	Feb., 1878			...do	
Willistown, Pa	Apr. 3, 1877			...do	
Chester County, Pa	Nov. 30, 1879				Do.
Pennsylvania	Jan. 5, 1881			Mice	
Barton, N. Y	Jan. 1, 1886			3 mice	
Elmira, N. Y	Jan. 21, 1886	Chicken			
Do	Apr. 5, 1886			Field mice	
Do	Aug. 18, 1887			Skunk	
Big Flats, N. Y	Sept. 5, 1887				Grasshoppers; beetles.
Corning, N. Y	Sept. 23, 1887			Field mice	Insects.
Greensborough, Ala	Feb. 25, 1888			Mouse	Lizard; grasshopper; cockroach; 3 crawfish.
Sandy Spring, Md	Mar. 17, 1888			Meadow mouse.	
Gainsville, Fla	Jan. 4, 1888				Spider.
Do	Jan. 18, 1888				4 mole crickets; 20 larvæ.

Summary.—Of 102 stomachs examined, 1 contained poultry; 5, other birds; 61, mice; 20, other mammals; 15, reptiles or batrachians; 40, insects; 7, spiders; 3, crawfish; 1, earthworm; 1 offal; 1 catfish; and 3 were empty.

SWAINSON'S HAWK (*Buteo Swainsoni*).

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Cedar County, Nebr	Aug., 1867.			Gopher	68 locusts.
Do	...do			...do	61 locusts.
Dakota County, Nebr	July, 1868			Rabbit	58 insects.
Sarpy County, Nebr	Sept., 1872			Gopher; mouse.	65 insects.

Summary.—Of 4 stomachs examined each one contained small mammals and insects.

BROAD-WINGED HAWK (*Buteo latissimus*).

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Sing Sing, N. Y	Sept. 19, 1885			Chipmunk	Crickets; grasshoppers.
Middle Haddam, Conn	Sept. 4, 1885				Toad.
London, Canada	Sept. 22, 1883				Toad; large number larvæ.
Lockport, N. Y	Apr. 27, 1886			Meadow mouse.	Snake; 2 beetles.
Brooklyn, Ohio	May 10, 1886			Chipmunk; shrew.	
Washington, D. C	June 5, 1887		3 oven birds	2 shrews	
Syracuse, N. Y	Apr. 30, 1887				Toad.
Roane Mountain, N. C	Aug. 10, 1887			Mouse	
Long Island City, N. Y	Sept. 23, 1887				Garter snake; toad; larvæ; beetles.
Do	Sept. 24, 1887				Larva.
Do	...do				Quantity of crickets.
Sing Sing, N. Y	Sept. 21, 1881				8 elm sphinx larvæ.

Statement of the stomach contents of more than 1,000 *Hawks and Owls*—Continued.

BROAD-WINGED HAWK (*Buteo latissimus*)—Continued.

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Sing Sing, N. Y	Sept. 23, 1881				Elm sphinx larvæ.
Lake George, N. Y	Aug. 2, 1882				Garter snake.
Sing Sing, N. Y	May 6, 1885				Quantity of earth worms.
Troy, N. Y	Sept. 19, 1885				Tree-frog; grasshoppers.
Sandy Spring, Md	May 10, 1887			Chipmunk; shrew.	
Do	Sept. 1, 1887				Grasshopper.
Chester County, Pa	May 28, 1878				Frog.
Elmira, N. Y	June 27, 1885			Large rat; field mouse.	
Do	Apr. 9, 1886			Weasel	
Do	July 3, 1887		Small bird		

Summary.—Of 22 stomachs examined, 2 contained small birds; 3, mice; 5, other mammals; 8, reptiles or batrachians; 10, insects; and 1, earth worms.

ROUGH-LEGGED HAWK (*Archibuteo lagopus-sancti johannis*).

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Chester County, Pa	Dec. 9, 1886			Shrew	
Northampton, Mass	Feb. 23, 1887			2 meadow mice	
Do	Feb. 16, 1887			7 meadow mice	
South Windsor, Conn	Mar. 29, 1887			Meadow mouse	
Portland, Conn	Mar. 30, 1887			6 meadow mice	
Northampton, Mass	Nov. 30, 1887			5 meadow mice	
Do	Dec. 2, 1887			Meadow mouse; house mouse.	
Do	Dec. 14, 1887			6 meadow mice	
Do	Dec. 20, 1887			3 house mice	
Do	Nov. 26, 1886			Meadow mice	
Do	Nov. 27, 1886			...do	
Do	Dec., 1886			...do	
Chester County, Pa	Feb., 1887			Meadow mouse	
Do	Jan. 28, 1879			Mice	
Do	...do			...do	
Do	Dec. 27, 1878			...do	
Do	Apr., 1876			...do	
Do	Mar. 20, 1880			...do	
Beatrice, Nebr	Sept., 1872			Gopher	Lizard; 70 insects.
Elmira, N. Y	Nov. 5, 1887			Rabbit	
Do	Jan. 3, 1888			Weasel	
Sandy Spring, Md	Mar. 17, 1888			2 meadow mice	
Northampton, Mass	Apr. 9, 1888			...do	
Do	Apr. 14, 1888			8 meadow mice	
Do	...do			2 meadow mice	
Do	Apr. 15, 1888				Empty.
Do	...do			2 meadow mice	
Do	...do			3 meadow mice	

Summary.—Of 28 stomachs examined, 23 contained mice; 4, other mammals; 1, lizard; 1, insects; 1 was empty. Seventeen stomachs examined by the division contained 52 mice.

GOLDEN EAGLE (*Aquila chrysaëtos*).

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Gaithersburgh, Md	Dec. 8, 1887				Carrion.

Summary.—The stomach examined contained carrion.

BALD EAGLE (*Haliæetus leucocephalus*).

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Sandy Spring, Md	Jan. 28, 1887				Carrion.
Oneida Lake, N. Y	Aug. 30, 1886				Sunfish.
Do	...do				Fish.
Sing Sing, N. Y	Feb. 27, 1881				Goldfish.
Paint Rock, Tex	Jan. 28, 1887			2 prairie dogs	
Gainesville, Fla	Jan. 13, 1888				Fish and offal.

Summary.—Of 6 stomachs examined, 1 contained mammals; 2, carrion; 4, fish.

Statement of the stomach contents of more than 1,000 *Hawks and Owls*—Continued.

PRAIRIE FALCON (*Falco mexicanus*).

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Sarpy County, Nebr	Sept., 1874		Prairie hen		16 locusts.

Summary.—The 1 stomach examined contained a game bird and insects.

DUCK HAWK (*Falco peregrinus anatum*).

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Portland, Conn	Apr. 29, 1886	Duck			Beetles.
East Bradford, Pa	Feb. 14, 1886		Feathers		
Do	Mar. 27, 1880	Fowl			
Watkins, N. Y	Oct. 28, 1887		Meadow lark		
Elmira, N. Y	Dec. 3, 1887			2 mice	

Summary.—Of 5 stomachs examined, 2 contained poultry and remains of game bird; 2, remains of other birds; 1, mice; 1, insects.

PIGEON HAWK (*Falco columbarius*).

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Shelter Island, N. Y	Sept. 11, 1886		Small bird		
Portland, Conn	May 6, 1886		Swift		
Lockport, N. Y	May 14, 1886		Song sparrow		
Rockville, Conn	Sept. 20, 1286				25 crickets; 6 grasshoppers.
Long Island City, N. Y.	May 3, 1886		English sparrow		
Sayville, N. Y	Sept. 14, 1887				Dragon flies; other insects.
East Hartford, Conn	Sept. 10, 1887		Small bird		
Sing Sing, N. Y	May 3, 1880		Feathers		
East Hartford, Conn	Sept. 24, 1886		Indigo bird		
West Chester, Pa	Feb. 20, 1878		Feathers		
Barton, N. Y	Aug. 2, 1886		Flicker		
Do	do			Field mice	Insects.
Do	Aug. 3, 1886			do	Do.
Elmira, N. Y	June 4, 1886		English sparrow		
Do	do		do		
Do	July 3, 1885				Grasshoppers; small beetles.
Horseheads, N. Y	Aug. 14, 1885				Small insects.
Elmira, N. Y	Aug. 29, 1885				Grasshoppers; beetles.
Gainesville, Fla	Jan. 4, 1888		Field sparrow; warbler.		

Summary.—Of 19 stomachs examined, 12 contained small birds; 2, mice; 7, insects.

SPARROW HAWK (*Falco sparverius*).

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Locust Grove, N. Y	Aug. 18, 1885				Spider; grasshoppers.
Sing Sing, N. Y	Sept. 22, 1885				Insect remains.
Washington, D. C	Nov. 3, 1885				Grasshoppers; crickets.
Alfred Centre, N. Y	Sept. 4, 1885				Larvæ.
Volusia County, Fla	Mar. 1, 1885				Lizard.
Do	Apr. 4, 1885				2 lizards; insect remains.
Peterborough, N. Y	July 13, 1886			Hair of mice	
Do	July 24, 1886				Grasshoppers; crickets.

Statement of the stomach contents of more than 1,000 *Hawks and Owls*—Continued.

SPARROW HAWK (*Falco sparverius*)—Continued.

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Peterborough, N. Y	July 24, 1886		Sparrow		Crickets.
Chester County, Pa	July 28, 1886				Grasshopper and crickets.
Do	do				Grasshoppers and crickets.
Do	Feb. 24, 1886				Larvæ.
East Windsor Hill, Conn.	Feb. 4, 1886				Empty.
Maplewood, N. J	Jan. 16, 1886		Song sparrow		
Do	May 25, 1886		Vireo		
Lockport, N. Y	Aug. 31, 1886				30 crickets.
Avon, Ohio	July 5, 1886				Remains of insects.
Baddeck, Nova Scotia	Aug. 13, 1886				Grasshoppers.
Gainesville, Fla	Apr. 20, 1887				Lizard; beetle; larvæ.
Harwood, Dak	July 13, 1887			Mouse	
Long Island City, N. Y	Sept. 16, 1887				Grasshoppers and crickets.
East Hartford, Conn	Sept. 9, 1887				Do.
Portland, Conn	Apr. 12, 1887			Meadow mouse.	Remains of insects.
Devil's Lake, Dak	Aug. 13, 1887				Snake; grasshoppers; crickets; larvæ.
Bottineau, Dak	Aug. 27, 1887				Cricket.
Washington, D. C	Dec. 24, 1887			House mouse	Grasshoppers; beetles.
Do	do				Grasshoppers.
Do	Dec. 25, 1887			House mouse	6 grasshoppers.
Do	Dec. 27, 1887		English sparrow		Grasshoppers.
Sing Sing, N. Y	Apr. 10, 1880				Do.
Do	Jan. 29, 1883			Meadow mouse.	
Do	Jan. 14, 1885			do	
East Hartford, Conn	Sept. 18, 1886		Song sparrow		
Do	July 16, 1886		Sparrow		Grasshoppers.
Do	Oct. 13, 1886			Meadow mouse.	Do.
Sandy Spring, Md	Jan. 28, 1887			do	
Do	Mar. 2, 1887			House mouse	Grasshopper.
Do	do			Mouse hair	
Do	do			House mouse	Remains of insects.
Do	do			Meadow mouse.	Do.
Do	do			White-footed mouse; house mouse.	
Do	do		Song sparrow		
Do	do				Do.
Do	Mar. 8, 1887		Song sparrow		15 crickets.
Do	Mar. 12, 1887				Grasshoppers; crickets; caterpillars; beetles.
Do	Mar. 18, 1887		Vesper sparrow		Larva.
Do	do			Meadow mouse.	Cricket; beetles.
Do	Mar. 24, 1887			House mouse	Cricket; larvæ.
Do	do				Empty.
Do	Apr. 1, 1887			Meadow mouse.	
Do	Apr. 8, 1887				Do.
Do	do			Meadow mouse.	Crickets; beetles; spider.
Do	Apr. [illegible]			Mouse	Spider.
Do	May 13, 1887			Meadow mouse.	Grasshoppers; white grubs.
Do	June 23, 1887				Grasshoppers and crickets.
Do	Sept. 26, 1887				Grasshoppers; spider.
Do	Oct. 28, 1887				Grasshoppers; crickets; spider.
Do	Jan. 2, 1888			Shrew	Grasshopper.
Do	Feb 22, 1888			Meadow mouse.	
Do	Nov. 26, 1887				Grasshoppers, etc.
Chester County, Pa	Apr. 3, 1886			Meadow mouse.	Caterpillars.
Do	Dec. 29, 1886			Mouse	
Do	Dec. 28, 1886			Meadow mouse.	Crickets; grasshoppers.
Do	Dec. 29, 1886		Sparrow		
Do	Jan. 17, 1886		Song sparrow	White-footed mouse.	
Do	Feb. 8, 1886		Tree sparrow	do	

Statement of the stomach contents of more than 1,000 *Hawks and Owls*—Continued.

SPARROW HAWK (*Falco sparverius*)—Continued.

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Chester County, Pa	Dec. 1, 1886			Meadow mouse	Grasshoppers; cricket; larvæ.
Do	Dec. 3, 1886				Beetle.
Do	Dec. 9, 1886		Junco		
Do	....do		Feathers	Meadow mouse; 2 shrews.	
Do	Dec. 16, 1886		....do		
Do	Nov. 26, 1886			Meadow mouse	Crickets.
Do	Feb. 7, 1887			....do	Crickets; caterpillars; spider.
Do	Jan. 12, 1887		Tree sparrow		
Do	Mar. 10, 1886				Empty.
Do	Jan. 6, 1885				Caterpillars; spider.
Do	Mar. 15, 1886				Empty.
Do				Meadow mouse	Grasshoppers; larvæ.
Do	Jan., 1887			....do	
Do	....do				8 Larvæ; spider.
Do	Dec. 20, 1886			Meadow mouse	Larva.
Do	Jan. 10, 1887		Song sparrow		
Do	Feb. 9, 1886				Grasshoppers; beetles; larvæ.
Do					Remains of insects.
Do				Meadow mouse	
Do	Jan., 1887			House mouse	Grasshoppers; 10 larvæ.
Do				Meadow mouse	Grasshopper larvæ; beetle.
Do	Jan. 25, 1887			House mouse	Crickets; larvæ.
Do	....do			Meadow mouse	5 grasshoppers; 5 larvæ; spider.
Do	....do			....do	
Do	Jan. 27, 1887			....do	
Do	Jan., 1887		Tree sparrow	....do	Caterpillar; crickets; spider.
Do	Feb. 1, 1887			White-footed mouse.	
Do	....do			2 meadow mice	
Do	....do				6 caterpillars; 6 grasshoppers; spider.
Do	Nov. 29, 1886				Insects.
Do	July 3, 1886				Do.
Do	Dec. 30, 1879		Meadow lark		
Do	Dec. 16, 1879		Junco	Mice	
Drayton Island, Fla	Feb. 20, 1885		Feather		Do.
Goshen, Pa	Jan. 12, 1881			Mice	
West Chester, Pa	Oct. 27, 1880				Do.
Chester County, Pa	Dec. 23, 1880		Meadow lark		Do.
Do	Jan. 12, 1881			Mice	
Do	Jan. 17, 1881			....do	
Do	Sept. 24, 1880				Grasshopper.
Do	Feb. 16, 1880			Mice	
Delaware County, Pa	Jan. 30, 1880			....do	
Chester County, Pa	Jan. 14, 1881			....do	
East Bradford, Pa	Jan. 1, 1880				Insects.
Chester County, Pa	Nov. 20, 1879				Do.
Do	Aug. 25, 1876			Mice	
Do	July, 1870			Bat	
Do	Jan. 16, 1879		Junco	Mice	
Dixon County, Nebr	July, 1865			Mouse	8 locusts; 27 other insects.
Dakota County, Nebr	....do			Gopher	38 insects.
Do	June., 1866	Quail			29 insects.
Do	July, 1866				34 insects.
Do	Aug., 1867			Rabbit	22 insects.
Cedar County, Nebr	....do			Mice	47 locusts.
Pierce County, Nebr	July, 1869			Gopher	40 insects.
Sarpy County, Nebr	Sept., 1871			Mice	37 insects.
Do	June, 1872		Birds		43 insects.
Lancaster Co., Nebr	Sept., 1873				40 insects; frogs.
Hale County, Ala	Mar. 17, 1888				Grasshoppers; crickets.
Gainesville, Fla	Jan. 4, 1888				Remains of insects.
Do	Jan. 9, 1888				Larvæ and other insects.

Statement of the stomach contents of more than 1,000 *Hawks and Owls*—Continued.

SPARROW HAWK (*Falco sparverius*)—Continued.

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Los Gatos, Cal	Dec. 7, 1887		Sparrow		
Do	Dec., 1887				Crickets.
Do	Jan. 19, 1885		Warbler		
Do	Dec. 31, 1887		Meadow lark; sparrow.		
Sandy Spring, Md	Apr. 2, 1888		Field sparrow		White grub; beetles; spider.
Chester County, Pa	Feb. 7, 1887				Caterpillar.

Summary.—Of the 133 stomachs examined, 1 contained game bird; 28, other birds; 55, mice; 6, other mammals; 5, reptiles or batrachians; 83, insects; 12, spiders; and 5 were empty.

BARN OWL (*Strix pratincola*).

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Chickamauga, Tenn	Nov. 27, 1885		Cowbird; sparrow.		
Chester County, Pa	May 21, 1886			Meadow mice	
Do	Dec. 8, 1886	Pigeon			
Dixon County, Nebr	Aug., 1867			Mouse	39 locusts; 22 other insects.
Dakota County, Nebr	July, 1868				55 insects.
Lancaster Co., Nebr	June, 1872			Mouse	40 insects.
Gainesville, Fla	Feb. 4, 1887			2 cotton rats; 2 shrews.	

Summary.—Of 7 stomachs examined, 1 contained poultry; 1, other birds; 4, mice; 1, other mammals; 3, insects.

LONG-EARED OWL (*Asio wilsonianus*).

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Cohuila Valley, Cal	Apr. 1, 1886			2 pocket mice	
Washington, D. C	Mar. 27, 1887		Song sparrow	Meadow mouse.	
Sheepshead Bay, L. I., N. Y.	Nov. 2, 1886		Junco; kinglet	....do	
Washington, D. C	Mar. 16, 1887				Empty.
Sandy Spring, Md	Mar. 8, 1887				Do.
Do	Mar. 12, 1887			Meadow mouse.	
Do	Mar. 18, 1887				Do.
Do	Nov. 19, 1887				Do.
Do	Jan. 7, 1888			2 meadow mice.	
Chester County, Pa	Jan. 11, 1887			Meadow mouse; 3 house mice.	
Do	Nov. 20, 1886			Meadow mouse.	
Do	Dec. 11, 1886			....do	
Do	Jan. 28, 1887			2 meadow mice.	
Do	....do			White-footed mouse; meadow mouse.	
Do				Meadow mouse.	
Do	Dec. 13, 1886			White-footed mouse; 2 meadow mice; shrew.	
Woodstock, Conn	June, 1887			4 meadow mice.	
Boston, Mass	Oct. 13, 1887		Sparrow; warbler.	Meadow mouse.	
Montgomery Co., Pa	Dec. 26, 1887			....do	
Sing Sing, N. Y	Apr. 29, 1880		Goldfinch; 2 sparrows.	Mouse	
Do	....do			2 mice	
Do	....do		Small bird	....do	
Chester County, Pa	Nov. 25, 1886			Mice	
Do	Nov. 10, 1878			....do	
Do	Dec. 30, 1884			....do	
Westtown, Pa	Feb. 23, 1879			....do	
Do	....do			....do	
Do	....do			....do	
Chester County, Pa	....do			....do	
Do	....do			....do	
Do	....do			....do	
Do	....do			....do	
Do	Nov. 22, 1880			....do	
Do	Dec. 5, 1879			....do	
Do	Feb. 25, 1880			....do	
Do	....do			....do	

Statement of the stomach contents of more than 1,000 *Hawks and Owls*—Continued.

LONG-EARED OWL (*Asio wilsonianus*)—Continued.

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Chester County, Pa	Feb. 25, 1880			Mice	
Do	...do			...do	
Do	...do			...do	
Dakota County, Nebr	July, 1865			Rabbit	Few insects.
Elmira, N. Y	Aug. 5, 1885			Field mice	
Do	Aug. 12, 1885			...do	
Do	Oct. 13, 1886			...do	
Do	...do			...do	
Nichols, N. Y	July 4, 1887				Empty.
Tioga, Pa	Sept. 2, 1887			Field mice	
Elmira, N. Y	Dec. 21, 1887	Quail			

Summary.—Of 47 stomachs examined, 1 contained a game bird, 5, other birds; 40, mice; 2, other animals; 1, insects; and 5 were empty.

SHORT-EARED OWL (*Asio accipitrinus*).

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Washington, D. C	Nov. 22, 1886		2 juncos; 1 fox sparrow.		
Oakdale, N. Y	Nov. 27, 1886			Mouse	
Rockville, Conn	Oct. 22, 1886			2 meadow mice.	
Do	...do			Mouse hair	
Koshkonong, Wis	Sept. 25, 1886			Meadow mouse.	
Washington, D. C	Apr. 20, 1887			3 meadow mice.	
Hillsborough, New Brunswick.	Sept. 3, 1887			2 meadow mice.	
Washington, D. C	Jan., 1887			1 meadow mouse	
Do	Mar. 28, 1887		Robin		
Hackensack, N. J	Mar. 31, 1887			2 meadow mice; 1 shrew.	
South Windsor, Conn	Mar. 29, 1887		Sparrow	2 meadow mice.	
Do	...do			...do	
Do	Nov. 4, 1887			...do	
Do	...do			5 meadow mice.	
Do	...do			4 meadow mice.	
Washington, D. C	Jan. 23, 1888			1 meadow mouse	
Glastonbury, Conn	Nov. 23, 1886				Empty.
Do	...do				Do.
East Hartford, Conn	Nov. 11, 1886			4 meadow mice.	
Do	Nov. 2, 1886			3 meadow mice.	
Sandy Spring, Md	Jan. 28, 1887			Meadow mouse.	
Do	Mar. 5, 1887			Mouse	
Do	...do				Do.
Do	...do				Do.
Do	...do			Mouse	
Do	Jan. 7, 1888			2 meadow mice.	
Do	Feb. 13, 1888				Do.
Chester County, Pa	Jan. 25, 1887			Meadow mouse.	
Do	Dec. 21, 1886			...do	
Do	Dec. 10, 1886			Pine mouse	
Do	Nov. 20, 1886			3 meadow mice.	
Do	Nov. 25, 1886			1 meadow mouse	
Do	Nov. 27, 1886		Feathers		
Do	Dec. 8, 1886			Meadow mouse.	
Do	Mar. 5, 1887				Do.
Do				Mice	
Do	Jan. 4, 1880			...do	
Do	Jan. 5, 1880			...do	
Dakota County, Nebr	July, 1870			Rabbit	17 insects.
Lincoln, Nebr	Sept., 1868			Gopher	30 locusts.
Elmira, N. Y	Aug. 13, 1884			Field mice	Beetle.
Do	Aug. 3, 1886			...do	Do.
Do	Aug. 7, 1886			...do	Do.
Erin, N. Y	Oct. 5, 1887			...do	Do.
Do	Dec. 29, 1887			...do	Do.

Summary.—Of 45 stomachs examined, 4 contained small birds; 34, mice; 3, other mammals; 7, insects; and 6 were empty.

Statement of the stomach contents of more than 1,000 *Hawks and Owls*—Continued.

BARRED OWL (*Syrnium nebulosum*).

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Englewood, N. J.	Feb. 22, 1886			Meadow mouse.	
Alfred Centre, N. Y.	Oct. 22, 1886			Red squirrel	
Whitewater, Wis	Aug. 30, 1886				Empty.
Washington, D. C.	Feb. 15, 1887				Do.
Do	Mar. 16, 1887			Shrew	Frog; 8 larvæ.
Greensborough, Ala	Nov. 15, 1887				Spider; grasshoppers; crickets.
Moose River, N. Y	June 10, 1878			12 red-backed mice.	
Sing Sing, N. Y	Nov. 27, 1882	Fowl			
Do	Jan. 21, 1885			2 meadow mice.	
Do	Mar. 21, 1885		Saw-whet owl		
Saint Louis, Mo	Spring, 1885		Screech owl		
Eubanks, Ky	Mar. 21, 1887			Meadow mice; rabbit.	
Greensborough, Ala	Nov. 12, 1887				Empty.
Sandy Spring, Md	Apr. 25, 1887				Crawfish.
Do	Nov. 14, 1887			4 meadow mice.	
Do	Nov. 28, 1887		Screech owl		
Do	Feb. 11, 1888				Empty.
Do	Feb. 18, 1888			Meadow mouse.	
Do	Feb. 19, 1888			Rabbit	
Chester County, Pa	Dec. 10, 1886			Flying squirrel	
Do	Dec. 16, 1886			Rabbit	
Do				Mice	
Do	Jan., 1880			do	
	Jan. 17, 1881			do	
Elmira, N. Y	Aug. 1, 1885				Frog; crawfish.
Do	Aug. 7, 1886			Several mice	
Waverly, N. Y.	Sept. 4, 1887			Mice	Insects.
Barton, N. Y	Oct. 17, 1886			Field mice	
Halsey Valley, N. Y	Oct. 5, 1887				Fish; insects.
Elmira, N. Y	Nov. 4, 1884			Mice	
Tyrone, N. Y	Nov. 13, 1887				Empty.
Elmira, N. Y	Dec. 1, 1886			Weasel	
Caton, N. Y	Jan. 1, 1885			Mice	
Tioga, N. Y	Feb. 9, 1886			Field mouse; mole.	
Elmira, N. Y.	Feb. 19, 1887		Small birds		
Do	Mar. 3, 1886			Field mice	
Alexandria, Va	Apr. 17, 1888				Do.

Summary.—Of 37 stomachs examined, 1 contained poultry; 4, other birds; 16, mice; 8, other mammals; 2, frogs; 4, insects; 1, spider; 2, crawfish; 1, fish; and 6 were empty.

FLORIDA BARRED OWL (*Syrnium nebulosum alleni*).

Gainesville, Fla	Apr. 20, 1887				Frog; crawfish; Grasshoppers; larvæ; beetle.
Do	May 9, 1887				Lizard.
Do	Dec. 29, 1887			Mouse	
Do	Feb. 19, 1888			do	

Summary.—Of 4 stomachs examined, 2 contained mice; 2, batrachian and reptile; 1, insects; 1 crawfish.

SAW-WHET OWL (*Nyctala acadica*).

Taunton, Mass	Dec. 11, 1885			Mouse hair	
East Hartford, Conn	Jan. 7, 1887			White-footed mouse.	
Hillsborough, N. B	Oct. 21, 1886			Mouse hair	
Flatbush, N. Y	Nov. 3, 1887			House mouse	
Locust Grove, N. Y	Jan. 24, 1884			Meadow mouse.	
Sing Sing, N. Y	Jan. 13, 1885			do	

Summary.—Of 6 stomachs examined, all contained mice.

Statement of the stomach contents of more than 1,000 *Hawks and Owls*—Continued.

SCREECH OWL (*Megascops asio*).

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Sing Sing, N. Y.	Aug. 31, 1885				Remains.
Atlanticville, N. Y.	Dec. 4, 1885			Mouse hair	
Sing Sing, N. Y.	Sept. 25, 1886				Do.
Washington, D. C.	Nov., 1886			Meadow mouse.	
Do	do			2 white-footed mice.	Do.
Do	do				Do.
Do	do				Do.
Do	do			Mouse hair	Do.
Do	do		Tree sparrow		
Do	do				Do.
Do	do		Feathers		
Do	do			Mouse hair	
Do	do				Do.
River Vale, N. J.	Nov. 20, 1885				Larvæ.
Bergen County, N. J.	Nov. 26, 1885			House mouse	
Alfred Centre, N. Y.	Oct. 10, 1886			White-footed mouse.	Grasshopper; crickets; crawfish.
Peterborough, N. Y.	Sept. 11, 1886		Sparrow	do	Grasshoppers.
Amherst, Mass.	July 8, 1886				Frog; remains.
Cleveland, Ohio	Mar. 12, 1886			Meadow mouse.	
East Hartford, Conn.	June 23, 1886		3 small birds		7 beetles.
Gainesville, Fla.	Mar. 12, 1887				Grasshoppers; larvæ of beetles.
Washington, D. C.	Jan., 1887			White-footed mouse; meadow mouse.	
Do	do			2 meadow mice.	
Do	do		Screech owl		
Do	do		do		
Do	Feb. 15, 1887			Mouse	
Rockville, Conn.	May 28, 1887				Empty.
Do	do				Beetle.
Portland, Conn.	Oct. 22, 1886				Spider.
Do	Dec. 23, 1886	Pigeon			
Lockport, N. Y.	Jan. 7, 1888				Crawfish.
Portland, Conn.	May 5, 1887				7 May beetles.
Washington, D. C.	Feb. 13, 1887			2 pine mice	
East Hartford, Conn.	July 16, 1886		2 English sparrows.		
Philadelphia, Pa.	Apr. 20, 1886				May beetles.
Greensborough, Ala.					2 cicadæ.
Sandy Spring, Md.	Mar. 2, 1887				Insects.
Do	do			2 mice	
Chester County, Pa.	Jan. 11, 1886			Mouse hair	
Do	Jan. 5, 1886			House mouse	
Do	Apr. 22, 1886		Feather		Beetle
Do	Jan. 7, 1887		Feathers		
Do	Jan. 8, 1887			House mouse	
Do	Nov. 10, 1887			Meadow mouse.	
Do	1876			Meadow mouse; house mouse.	
Do	Nov. 27, 1886			White-footed mouse.	
Do	do				Empty.
Do	Dec. 6, 1886			Meadow mouse.	
Do	Dec. 10, 1886				Beetles.
Do	do				Empty.
Do	Feb. 12, 1887				Indeterminate matter.
Do	Feb. 9, 1887			House mouse	
Do	Feb. 18, 1887			do	
Do	Jan. 15, 1887			do	
Do	Jan. 17, 1887			do	
Do	Dec. 27, 1886			Mouse hair	
Do	Jan. 11, 1887			House mouse	
Do	Feb. 9, 1887				Trace.
Do	Feb. 10, 887				Empty.
Do	Jan. 17, 1887			Mouse hair	
Do	Feb. 11, 1887				Do.
Do	June 7, 1884				Insects.
Do	Jan. 8, 1885				Do.
Do	Jan. 6, 1885				Do.
Do	Dec. 18, 1886		English sparrow	Mice	
Do	Nov. 17, 1880		+	+	
Do	Nov. 26, 1880			Mice	
Do	Aug. 20, 1876				Grasshoppers.
Delaware County, Pa.	Dec. 5, 1879			Mice	

Statement of the stomach contents of more than 1,000 *Hawks and Owls*—Continued.

SCREECH OWL (*Megascops asio*)—Continued.

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Cedar County, Nebr	Sept., 1867				47 locusts; 12 other insects.
Do	do		Small bird		32 locusts; 8 other insects.
Do	June, 1868				41 locusts; 22 other insects.
Dakota County, Nebr	July, 1869			Mouse	69 insects.
Do	Aug., 1870			do	38 insects.
Seward County, Nebr	Sept., 1872				67 insects.
Nemaha County, Nebr	Sept., 1874				50 locusts; 16 other insects.
Lancaster Co., Nebr	June, 1875				49 locusts; 15 other insects.
Elmira, N. Y	Jan. 29, 1886		English sparrow	Mice	
Do	Jan. 30, 1886		Feathers	do	
Horseheads, N. Y	Feb. 4, 1886		English sparrow		
Chemung, N. Y	Mar. 7, 1886			Field mice	
Elmira, N. Y	Mar. 21, 1886			Mice (?)	
Barton, N. Y	Apr. 13, 1887		Junco		
Waverly, N. Y	Apr. 15, 1886				Insects.
Tioga, Pa	Oct. 5, 1886			Mice	
Wellsborough, Pa	Oct. 8, 1887		English sparrow		
Elmira, N. Y	Oct. 21, 1886		Shore lark		
Do	Oct. 23, 1886			Mice	
Do	Oct. 25, 1887		English sparrow		
Wellsburgh, N. Y	Nov. 2, 1886				Empty.
Caton, N. Y	Dec. 24, 1887		English sparrow		
Washington, D. C	Mar. 25, 1888			Meadow mouse	Crawfish.
Do	do				Empty.
West Chester, Pa	Jan. 6, 1887			House mouse	

Summary.—Of 94 stomachs examined, 1 contained poultry; 20, other birds; 41, mice; 1, other mammal; 1, frog; 35, insects; 3, crawfish; 1, spider; 1, indeterminate matter; and 7 were empty.

GREAT HORNED OWL (*Bubo virginianus*).

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Chattanooga, Tenn	Dec. 25, 1885	Quail			
New London, Wis	Oct. 25, 1886			Fox squirrel	
Chester County, Pa	May 11, 1886	Guinea fowl.			
Adairsville, Ga	May 20, 1886				Beetle.
Lockport, N. Y	Jan. 2, 1887	Fowl			
Do		do			
East Hartford, Conn	June 16, 1887	do		Rabbit	
Sing Sing, N. Y	Jan. 19, 1883	Guinea fowl.			
Do	July 9, 1884	Fowl	Robin		
Do	Nov. 12, 1884			Shrew	
Do	Feb. 26, 1885			Rabbit	
Paint Rock, Tex	Apr. 23, 1887		Cooper's hawk; lark-finch; mockingbird.		
Sandy Spring, Md	Mar. 12, 1887	Pigeon		Meadow mouse.	
Chester County, Pa	Feb. 15, 1886			Rabbit	
Do	Sept., 1878	+			
Dakota County, Nebr	July, 1869			Gopher	30 insects.
Elmira, N. Y	Oct. 4, 1885			Skunk	
Do	Oct. 7, 1886	Ruffed grouse.			
Corning, N. Y	Aug. 15, 1884			Gray squirrel	
Tyrone, N. Y	Sept. 4, 1886	Poultry			
Elmira, N. Y	Nov. 5, 1885	do			
Breesport, N. Y	Nov. 2, 1886			Rabbit	
Canton, Pa	Dec. 13, 1884			Skunk	
Tioga, Pa	Dec. 15, 1884			Weasel (?)	
Gaines, Pa	Dec. 29, 1885	Ruffed grouse.			
Elmira, N. Y	Jan. 3, 1884	Poultry			Empty.
Do	Jan. 5, 1885				
Big Flats, N. Y	Jan. 17, 1886	Poultry			
Erin, N. Y	Jan. 29, 1887	Ruffed grouse.			
Sandy Spring, Md	Apr. 7, 1888			Rabbit	

Summary.—Of 30 stomachs examined, 16 contained poultry or game birds; 2, other birds; 1, mice; 12, other mammals; 2, insects; and 1 was empty.

Statement of the stomach contents of more than 1,000 *Hawks and Owls*—Continued.

SNOWY OWL (*Nyctea nyctea*).

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Washington, D. C.	Nov. 11, 1885				Empty.
Portland, Conn	Nov. 20, 1885				Do.
Keokuk, Iowa	Dec. 6, 1886	Prairie hen.		Meadow mouse.	
Lockport, N. Y.	Nov. 17, 1886				Do.
Do.	...do				Do.
Chester County, Pa.	Dec. 14, 1886			House rat	

Summary.—Of 6 stomachs examined, 1 contained game bird; 2, mice; and 4 were empty.

HAWK OWL (*Surnia ulula caparoch*).

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Quebec, Canada	Jan. 15, 1886			Meadow mouse.	

Summary.—The 1 stomach examined contained a mouse.

BURROWING OWL (*Speotyto cunicularia hypogæa*).

Locality.	Date.	Poultry or game birds.	Other birds.	Mammals.	Miscellaneous.
Fort Buford, Dak	Sept. 29, 1887				Grasshoppers.
Wayne Co., Nebr.	June, 1868				62 insects.
Do.	...do				Lizard; 30 insects.
Pierce Co., Nebr.	...do				49 locusts; 17 other insects.
Do.	...do			Prairie dog	46 locusts; 10 other insects.
Do.	...do				54 locusts; 8 other insects.
Wayne County, Nebr.	July, 1869			Mouse	65 insects.
Sydney, Cheyenne County, Nebr.	June, 1875				59 locusts; 3 other insects.
Ogalalla, Keith County, Nebr.	Sept., 1876			Mouse	51 locusts; 12 other insects.
Do.	...do				58 locusts; 4 other insects.

Summary.—Of 10 stomachs examined, 2 contained mice; 1, other mammal; 10, insects.

SUMMARY OF STOMACHS EXAMINED.

Swallow-tailed Kite (*Elanoides forficatus*)	5
Mississippi Kite (*Ictinia mississippiensis*)	2
Marsh Hawk (*Circus hudsonius*)	46
Sharp-shinned Hawk (*Accipiter velox*)	48
Cooper's Hawk (*Accipiter cooperi*)	46
Goshawk (*Accipiter atricapillus*)	6
Red-tailed Hawk (*Buteo borealis*)	311
Red-shouldered Hawk (*Buteo lineatus*)	102
Swainson's Hawk (*Buteo swainsoni*)	4
Broad-winged Hawk (*Buteo latissimus*)	22
Rough-legged Hawk (*Archibuteo lagopus sancti-johannis*)	28
Golden Eagle (*Aquila chrysaëtos*)	1
Bald Eagle (*Haliæetus leucocephalus*)	6
Prairie Falcon (*Falco mexicanus*)	1
Duck Hawk (*Falco peregrinus anatum*)	[illegible]
Pigeon Hawk (*Falco columbarius*)	19
Sparrow Hawk (*Falco sparverius*)	133
Total number of hawks	785
Barn Owl (*Strix pratincola*)	7
Long-eared Owl (*Asio wilsonianus*)	47
Short-eared Owl (*Asio accipitrinus*)	45
Barred Owl (*Syrnium nebulosum*)	37
Florida Barred Owl (*Syrnium nebulosum alleni*)	4
Saw-whet Owl (*Nyctala acadica*)	6
Screech Owl (*Megascops asio*)	94
Great Horned Owl (*Bubo virginianus*)	30
Snowy Owl (*Nyctea nyctea*)	6
Hawk Owl (*Surnia ulula caparoch*)	1
Burrowing Owl (*Speotyto cunicularia hypogæa*)	10
Total number of owls	287
Total number of hawks	785
Total number of hawks and owls	1,072

EXPERIMENTS IN POISONING.

By Dr. A. K. Fisher, *Assistant Ornithologist.*

So little definite information is available concerning practical methods of destroying injurious species of birds and mammals by poisons, and so many letters of inquiry have been received by the Department asking for detailed instructions on the subject, that it has been found necessary to conduct a series of experiments in order to obtain the desired information. It was important to determine not only what poison is most efficient and best adapted for the purpose, but also the most economical poison, the quantity necessary for use, and the simplest method of preparation. As an easily accessible and hardy bird, and one which could be procured in any desired numbers, the English Sparrow was selected as the first species to be experimented upon. A large number of healthy English sparrows were secured and confined in large cages. They were given an abundance of food and water during the time covered by the experiments, so that they might not be forced from hunger to partake of the poisoned grain.

POISONS USED IN THE EXPERIMENTS.

The following poisons were used in the experiments:

- Strychnine.
- Arsenic.
- Corrosive sublimate.

Of strychnine, two preparations were used:

- Crystals of strychnine.
- Tincture of nux vomica.

Of arsenic, the following preparations were used:

- Arsenious oxide (white arsenic).
- Arsenite of copper (Paris green).
- Arsenite of calcium (London purple).
- Arseniate of soda.
- Liq. Potassii arsenitis (Fowler's solution).

POISONS RECOMMENDED.

The results of these experiments have led to the recommendation of the following formulæ as simple, efficacious, and inexpensive:

Arsenic.—One part by weight of white arsenic to fifteen parts of corn meal or grain. (Paris green and London purple would be just as valuable as white arsenic, except for their bright color, which arouses the sparrow's suspicion.)

Directions.—If corn meal is used, the arsenic should be stirred in dry, and the mixture afterward moistened. It should be fed moist. If whole grain is used, it should be moistened before stirring in the arsenic. It will be found advantageous to add a little gum arabic to the water used to moisten the grain, as it causes the poison to adhere more firmly to the kernels. It should be dried before using. Wheat is preferable to all other grain, because the sparrows feed upon it more eagerly.

Strychnine.—Dissolve 2 grams of strychnine in a liter of hot water. (Ordinarily strychnine is put up in bottles containing one-eighth of an ounce. Half of the contents of one of these bottles, dissolved in a quart of hot water, gives a solution of the desired strength.)

Directions.—To insure the best results it is necessary to soak the grain in the poison solution at least forty-eight hours. It should then be dried. Grain prepared in this way may be kept in jars, to be used as required.

Corrosive sublimate, cyanide of potassium, phosphorus, and a number of other poisons, although efficient, can not be recommended on account of the danger attending their use.

GENERAL SUGGESTIONS.

In dealing with as suspicious a bird as the English Sparrow, in cases where the continued use of the poison is required, a slow poison (such as arsenic) is preferable to one of rapid action (such as strychnine), for the reason that the effects of the latter may become apparent in certain individuals while the birds are still feeding, the peculiar actions of the affected birds frightening the others away before they have taken enough of the poisoned grain to insure fatal results. In such cases it has been observed that the frightened birds never return to the grain.

Before putting out poison for sparrows, the birds should be baited to a certain locality. At the same hour each day they should be fed with the same kind of grain that subsequently is to be used as the vehicle for the poison.

PRECAUTIONS.

In the use of poisons the utmost caution is necessary to prevent the possibility of accident from the poison itself, or from the grain employed as a vehicle for the poison. The following precautions should be observed: (1) All vessels containing poison or poisoned grain, and those in which the same are mixed, should be labeled with the word *Poison*, in large letters; (2) all vessels containing poison or poisoned grain should be kept out of reach of children and domesticated animals; (3) in preparing and exposing poisoned grain, great care should be taken to avoid spilling any of it where it might be found by children, farm animals, or poultry.

Another possible source of danger in the use of poisons, and one that is much less easy to guard against, arises from the fact that the bodies of the poisoned birds are liable to fall where they may be picked up and eaten by man or beast. However, very little real danger is to be apprehended from this source.

SYNOPSIS OF EXPERIMENTS.

Following is a brief synopsis of the experiments in poisoning made by the division:

EXPERIMENTS WITH STRYCHNINE.

No. 1. (1 bird.) Fed on wheat soaked one and a half hours in a solution of strychnine (.65 of a gram to 30 c. c. of cold water) and dried. Bird commenced eating at 1.16 p. m. At 1.27 p. m. showed first symptoms. At 3.10 p. m. it had apparently nearly recovered. Next morning it was dead. Stomach and crop contained 9 kernels of wheat.

No. 2. (1 bird.) Fed on hemp seed soaked twenty-four hours in a solution of strychnine (.325 of a gram to 30 c. c. of cold water) and dried. Bird commenced eating at 11.35 a. m.; died at 12.20. Crop contained 3 shelled hemp seeds; stomach none.

No. 3. (3 birds.) Fed on hemp seed soaked twenty-four hours in a solution of strychnine (.65 of a gram to 30 c. c. of cold water) and dried. Commenced feeding at 12.15 (it is impossible to say that all three commenced at that time). Bird No. 1 died at 12.42. Crop contained 3 shelled hemp seeds; none in stomach. Bird No. 2 at about 1 o'clock showed first symptoms while eating; at 3.10, however, it had partially recovered. It was dead the next morning, Stomach and crop contained 4 to 5

kernels. Bird No. 3 ate the poisoned hemp seed and non-poisoned wheat until 3.10 p.m., seemingly without bad results. It was dead next morning. Three kernels of hemp seed were all that could be discovered in the stomach and crop, which contained also 10 to 12 kernels of non-poisoned wheat.

No. 4. (2 birds.) Fed on wheat soaked forty-five hours in a solution of strychnine (.325 of a gram to 30 c.c. of cold water) and dried. Commenced eating at 10.20; both dead at 11.05. Each had eaten 3 kernels of wheat.

No. 5. (1 bird.) Fed same as above. Commenced eating at 12.30; died at 1.14 p.m. Stomach contained wheat partially digested; nothing in crop.

No. 6. (1 bird.) Fed on oats soaked twenty hours in a solution of strychnine (.65 of a gram to 30 c.c. of cold water) and not dried. Bird commenced eating about 11 o'clock, but seemed not to relish the food. At 11.20 the bird was unsteady in its movements, but at 3.45 it was in good condition. Next morning had wholly recovered; probably did not eat enough of the poisoned grain.

No. 7. (2 birds.) Fed on non-poisoned hemp seed and wheat, and given water to drink containing .325 of a gram of sulp. strychnine to 30 c. c. of water. Four hours afterward they were visited, and both were found dead and cold.

No. 8. (5 birds.) Fed on wheat soaked for forty-eight hours in a solution of strychnine (.16 of a gram to 30 c. c. of water). Commenced eating at 11.45 a. m. At 1.45 p. m. two were dead. At 2 p. m. the third was dead. At 3 p. m. the fourth was dead. The last was found dead the next morning.

No. 9. (2 birds.) Fed on wheat soaked for forty-eight hours in solution of strychnine (.065 of a gram to 30 c. c. of water). Commenced eating at 10 a. m. First bird died at 10.45. Its stomach and crop contained 10 kernels of wheat. At 11.10 the second bird died. Its crop contained 4 kernels; stomach empty.

No. 10. (5 birds.) Fed on wheat soaked forty-eight hours in solution of strychnine (.03 of a gram to 30 c. c. of water). Commenced eating at 1 p. m. At 2 p. m. the first bird was dead, and another badly affected, but recovered. Two were dead next morning. The fifth bird was not affected; probably did not eat enough. This solution would seem to be too weak to give certain results.

EXPERIMENTS WITH TINCTURE OF NUX VOMICA.

No. 11. (3 birds.) Fed on wheat soaked twenty-four hours in tincture of nux vomica and dried. At 10.30 a. m. one bird eating; at 10.55 affected; at 1.15 p. m. symptoms passing off; recovered. At 1.15 p. m. second bird dead; stomach contained 8 kernels of wheat; crop empty. Another bird commencing to eat at 11 a. m.; died at 1.10 p. m.; stomach contained 4 kernels of wheat; crop none.

EXPERIMENTS WITH CORROSIVE CHLORIDE OF MERCURY (CORROSIVE SUBLIMATE).

No. 12. (2 birds.) Fed on wheat soaked twenty-four hours in a saturated solution (in water) of corrosive sublimate and dried. Birds commenced to eat at 10.30 a. m. First bird died at 1.15 p. m.; stomach and crop empty. Second bird died at 3 p. m.; 2 kernels of wheat in stomach; crop empty.

EXPERIMENTS WITH WHITE ARSENIC.

No. 13. (1 bird.) Fed on Indian meal and white arsenic (15 to 1) mixed with a little water. Commenced to eat immediately (9.45 a. m.). At 3.45 bird still in good spirits. Dead next morning. Stomach and crop empty.

No. 14. (1 bird.) Fed same as No. 13. Commenced to eat at 9.30 a. m.; badly affected at 2 p. m.; dead at 2.54 p. m. Stomach and crop empty.

No. 15. (3 birds.) Fed same as Nos. 13 and 14. Commenced to eat at 8.45 a. m. At 3 p. m. two affected and one seemed in good spirits. All were dead next morning. Stomachs and crops empty.

No. 16. (2 birds.) Fed on Indian meal and white arsenic (15 to 2), moistened. Commenced to eat at 10.30 a. m. First bird died at 3 p. m. Stomach and crop empty. Second bird affected at 3.20; dead next morning.

EXPERIMENTS WITH ARSENIATE OF SODA.

No. 17. (1 bird.) Fed on hemp seed soaked one and a half hours in a solution of arseniate of soda (1.56 grams to 30 c. c. water) and dried. The bird ate freely, but recovered.

No. 18. (1 bird.) Fed on hemp seed soaked one and a half hours in a solution of arseniate of soda (2.10 grams to 30 c. c. water) and dried. Dead (time not taken). Stomach and crop contained 12 hemp seed.

No. 19. (2 birds.) Fed on wheat soaked three hours in a solution of arseniate of soda (2.10 grams to 30 c.c. water) and dried. Commenced to eat at 9.30 a.m. First bird dead at 10.35 a.m.; crop empty; stomach contained four kernels. Second bird dead at 2.35 p.m.; crop and stomach empty.

EXPERIMENT WITH LIQUOR POTASSII ARSENITIS (FOWLER'S SOLUTION).

No. 20. (2 birds.) Fed on wheat soaked seventy-two hours in Fowler's solution of arsenic (liq. Potassii arsenitis). Commenced eating at 10 a.m.; lively at 4 p.m. Both dead next morning.

EXPERIMENTS WITH ARSENITE OF CALCIUM (LONDON PURPLE).

No. 21. (1 bird.) One hungry bird exposed to ground hemp seed and London purple (15 to 1) for five hours, but would not touch it on account of its marked color.

NOTE.—When mixed with whole grain the color is not so conspicuous. (See next experiment.)

No. 22. (3 birds.) Fed on wheat and London purple (15 to 1) stirred up with a little gum-arabic water and then dried. Commenced eating at 9.45 a.m. First one dead at 3.30 p.m.; stomach and crop empty. Second and third badly affected at 3.30 p.m.; dead next morning; stomach and crop empty.

EXPERIMENTS WITH ARSENITE OF COPPER (PARIS GREEN).

No. 23. (3 birds.) Three hungry birds exposed to ground hemp seed and Paris green for four hours, and refused to eat it on account of its bright color.

No. 24. (3 birds.) Fed on wheat and Paris green (15 to 1) stirred up with a little gum-arabic water and then dried. Commenced to eat at 9.45 a.m. First bird dead at 3.30 p.m.; stomach and crop empty. Second and third birds badly affected at 3.30 p.m.; dead next morning; stomachs and crops empty.

REPORT ON SOME OF THE RESULTS OF A TRIP THROUGH PARTS OF MINNESOTA AND DAKOTA.

By VERNON BAILEY, *Field Agent.*

Mr. Bailey was employed by the division to make field investigations in Minnesota and Dakota for the purposes set forth in the accompanying letters of instruction:

UNITED STATES DEPARTMENT OF AGRICULTURE,
COMMISSIONER'S OFFICE,
Washington, D. C., May 4, 1887.

SIR: You are hereby appointed a special field agent of the Division of Economic Ornithology and Mammalogy of this Department, * * * your appointment to date from May 10, instant.

You will set out on an expedition for the purpose of investigating the food habits and distribution of the mammals and birds of certain parts of Minnesota and Dakota. You will proceed direct to Round Lake, Nobles County, Minn., to investigate the damages inflicted upon the newly-planted corn by Blackbirds, of which grievous complaints have been made to me by the farmers of that region. You will determine the species which occasion the damage, examine their breeding-grounds, and suggest such measures as you may deem practicable for the relief of the losses they sustain. From Round Lake you will proceed to Heron Lake (Jackson County) for the purpose of ascertaining positively what species of birds breed at that place, concerning which very remarkable reports have reached the Department. From Heron Lake you will cross the boundary into Dakota, and work northward to the Fort Sisseton Indian Reservation and the Traverse Lake region (including Big Stone Lake), on the boundary line, visiting points on both shores. Thence proceed north, in the Red River valley, to Pembina, collecting as much information as possible concerning the depredations of Gophers in that region, and determining in each case which species of Gopher is responsible for the injury. Throughout the trip you will make a special study of the habits of the peculiar in-

sectivorous Mouse, known as the Missouri Grasshopper Mouse (*Hesperomys leucogaster*).

From Pembina you will proceed, if practicable, to the Turtle Mountain region, and thence to Forts Berthold and Buford on the Missouri. If this route is not practicable, you will proceed from Pembina to Devil's Lake (in Ramsey and Benson Counties); thence to old Fort Berthold, and thence to Fort Buford. Before leaving this part of Dakota you will visit the a[illegible]rea, and will ascend the Little Missouri as far as practicable. Thence proceed by the most direct available route to the Black Hills of Dakota. It may be necessary to descend the Missouri to Fort Abraham Lincoln, and thence, by the old post-road, proceed to Fort Meade. You will visit some of the higher mountains of the Black Hills and determine their fauna. Thence proceed to the "Bad Lands," and the "Sand Hill Desert" just south of it, remaining long enough at each place to learn the peculiarities of its fauna, and the principal food of the species which live there.

You will receive detailed instructions for your routine field work from the Ornithologist of this Department.

Respectfully,

NORMAN J. COLMAN.
Commissioner.

VERNON BAILEY, Esq.,
Elk River, Minn.

UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF ECONOMIC ORNITHOLOGY AND MAMMALOGY,
Washington, D. C., May 5, 1887.

DEAR SIR: In obedience to your commission, which this letter accompanies, you will set out for Round Lake, Minn., on the 10th instant, for the special purpose of investigating the damage done the newly-planted corn crop by Blackbirds. If on your arrival at Round Lake you learn that the season is so backward that corn will not be up for a week or ten days, you will proceed at once to Heron Lake (for the purpose specified in your commission).

Unless you find a particularly promising locality in southeastern Dakota you had better proceed at once to Fort Sisseton and the Traverse Lake region, where you ought to stay about two weeks.

* * * * * * *

Before leaving any locality at which you have stopped a few days give a brief account of the more important physical features of the place. This will help explain any peculiarities which the species found there may suggest.

You will make a collection of the stomachs and gizzards of birds, in accordance with instructions contained in Circular 4, of which a copy is inclosed.

Respectfully,

C. HART MERRIAM,
Ornithologist.

Mr. VERNON BAILEY,
Elk River, Minn.

Supplementary instructions were sent from time to time, but the above sufficiently cover the objects and general direction of the expedition.

Mr. Bailey was in the field about five months, during which time he made a valuable collection of the stomachs of birds and mammals of economic importance, and secured much useful information concerning their food habits and distribution. His report is too bulky to be printed as a whole, hence portions relating to Blackbirds and mammals, together with his descriptions of the localities visited, have been selected and arranged for publication as a part of the present report. For the determination of the specimens collected, and for the nomenclature employed, the ornithologist of this department is responsible.

BLACKBIRDS.

Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*).

Heron Lake, Jackson County, Minn., May 14, 1887.—These birds are very numerous here, and do more damage to crops than at Round Lake. No corn can be raised on account of them, and it is hard work to get a crop of wheat, oats, or flax, without more or less injury from them.

The species of Blackbirds most numerous here, and of which most complaint is made, are the Yellow-headed and Red-winged. The Purple Grackle, Cowbird, and Bobolink are present, but in less numbers; consequently the damage they do is not of so much importance. The Yellow-heads and Red-wings seem to be in about equal numbers and of much the same habits, nesting in company among the reeds and coarse grass of the slough and borders of lakes. Their nests are almost always placed in bunches of grass surrounded by water; this is of importance, because where there are no suitable breeding places there are no blackbirds. The reason the blackbirds are so numerous here evidently is because the prairies contain a great many sloughs or wet marshes, with coarse grass and reeds growing in and around them. Here the birds build their nests, going to the surrounding fields for food. For information regarding the injury done corn I have had to depend almost entirely on what I could learn from the farmers, as very little corn is planted here this year. I could hear of but one field (8 acres); it was 5 miles from town and 2 miles from the lake. This I visited, but found the corn not yet up (May 21). A forkful of manure had been placed over each hill to keep the birds from finding it as soon as out of the ground. The farmers near Heron Lake say it is of no use to plant corn at all, as they can not keep the birds off. Mr. Thomas Miller, who lives near the lake, says he planted a piece of corn last year, and that by constant watching with a shot-gun, and planting over the hills that had been pulled up for the second time, he succeeded in raising about two-thirds of the hills planted; and then in the fall the birds destroyed a large part of that before it ripened. He says the birds do as much damage to the crops before harvest in the fall as they do in taking the seed in the spring.

The principal crops raised here are wheat, oats, and flax. These crops are now so far advanced that the birds can not injure them much more, but they are still constantly visiting the fields, and the stomachs preserved will show what their food is. All through the fields of flax, wheat, and oats are spaces bare of grain and coming up to weeds.

In the latter part of summer the Blackbirds are said to congregate in large flocks and devour and break down a great deal of wheat, oats, and barley just before it ripens. I can not learn positively what species are responsible for this damage; probably the Rusty Grackle is one.

I can not suggest any means of immediate relief, but believe that the extermination of the Blackbirds, especially the Yellow-headed, Red-winged, and Purple and Rusty Grackles, would be of great advantage to the farmers. But how is this to be done? I do not think by the shot-gun, for I have found it very difficult to get specimens for stomachs in that way. They are so shy that it is difficult to ap-

proach within shooting distance. The only way I could kill them was to get where they fly from the lake to the fields and shoot them as they passed. I am told that they will not eat grain soaked in strychnine or arsenic, but I think a series of experiments in poisoning them might be profitable. They seem easily baited, and perhaps could be caught in nets like pigeons.

The legislature of Minnesota has authorized the county commissioners to allow a bounty on Blackbirds and Gophers, but in this county no action has been taken in the matter, and the people do not seem to think it much use. Perhaps the birds could be killed when they have young by going among their nests.

Round Lake, Nobles County, Minn., May 12, 1887.—Abundant. A great many are just beginning to build nests.

Ortonville, Big Stone County, Minn., June 13, 1887.—Numerous; breeding in the reeds along the lake. Found 21 nests in going about 40 rods along the shore. They were all built in the reeds, and were from 1 to 5 feet high. Two nests had sets of four eggs; two of three; one of two; one of one; one three young and one egg; and two had shells of eggs. Twelve nests were empty, though all completed. Most of the empty nests were over dry ground. Only one nest on dry ground had eggs; it was 4½ feet high. Most of the nests over water contained eggs.

Brown's Valley, Traverse County, Minn., June 21 to July 8, 1887.—Numerous; a great many breed in the reeds at the south end of Lake Traverse. June 23, all the young were out of the nests, and many of the adults had gathered into loose flocks along with Purple Grackles, Red-wings, and Cowbirds, and were feeding on a field of Hungarian grass (*Setaria italica*) which has just been sown. This field contains about 80 acres, and I estimated that there were not less than 300 Blackbirds and 100 Mourning Doves on it at one time. The stomachs sent will show their food.

Graceville, Big Stone County, Minn., July 11, 1887.—There are two clear lakes here surrounded by timber, and in places by high grass, rushes, and reeds. There is a large slough with rushes and grass. Here I found large flocks of Blackbirds (seemingly composed of about equal numbers of Red-wings, Yellow-heads, and Purple Grackles). There was a flock of about 200 near the elevator when the train came in, and many small flocks and loose birds were picking grain in the streets. Having to wait seven hours for the train, I went among the sloughs and found the birds very numerous. Many young that could fly only a short distance were in the grass. Many of the adult Yellow-heads were in the midst of their moult, the new black feathers showing plainly among the old rusty ones. Their wings were generally ragged, and some were minus a tail. The moult was not noticeable among the Red-wings and Purple Grackles at a distance. Later in the afternoon I saw several large flocks in the wheat and oat fields. This is the first time I have seen them feeding on grain.

Flandreau, Moody County, Dak., May 25–31, 1887.—Saw one pair; they do not stay here.

Fort Sisseton, Marshall County, Dak., June 15–18, 1887.—Numerous about the sloughs.

Harwood, Cass County, Dak., July 12–15, 1887.—Common.

Devil's Lake, Ramsey County, Dak., August 6–19, 1887.—Numerous in large flocks with Red-wings, Cowbirds, and Purple Grackles, and feeding on wheat and oats. They seem to prefer ripe grain, and feed from the shocks. They are about in equal numbers with Red-wings.

Bottineau, Dak. (western edge of Turtle Mountain), August 22–30, 1887.—Scarce; have seen but 2 or 3 in flocks with other Blackbirds.

Fort Buford, Dak., September 1–20, 1887.—About 20 were in the flocks of other blackbirds at first, but none were seen after about September 10. They were feeding on grasshoppers and wild sunflower seeds.

RED-WINGED BLACKBIRD (*Agelaius phœniceus.*)

Round Lake, Nobles County, Minn., May 12, 1887.—Numerous.

Heron Lake, Jackon County, Minn., May 14, 1887.—Numerous; breeding. Great complaints are made of their depredations. (See remarks under Yellow-headed Blackbird.)

Ortonville, Big Stone County, Minn., June 13, 1887.—Not numerous.

Brown's Valley, Traverse County, Minn., June 21–July 8, 1887.—Numerous.

Graceville, Big Stone County, Minn., July 11, 1887.—Numerous; feeding on grain. (See Yellow-headed Blackbird.)

Flandreau, Moody County, Dak., May 23–31, 1887.—Not numerous; a few breed along the banks of the river and in the bushes. Found one nest in a bush 4 feet high, and one in a bush 8 feet high.

Fort Sisseton, Marshall County, Dak., June 15–18, 1887.—Numerous.

Harwood, Cass County, Dak., July 12–15, 1887.—Common.

Pembina, Dak., July 21–August 2, 1887.—Have not seen more than 5 or 6 except at a slough where there was a flock of about 20

Devil's Lake, Ramsey County, Dak., August 6–19, 1887.—Numerous in large flocks (from 1,000 to less). As near as I can judge these flocks are composed of about 40 per cent. Red-wings, 40 per cent. Yellow-heads, 15 per cent. Cowbirds, and 5 per cent. Purple Grackles. Sometimes they separate into flocks composed mainly of one species, but are constantly changing and mixing. The grain-fields near a lake or grove suffer most, while those far from either are seldom visited. The birds begin to feed at sunrise, and remain in or near the field until about sundown, when large flocks pour into the reeds near the lake to roost. Besides what they eat, they shell and knock off much grain, and where it has become thoroughly ripe before being cut the ground is covered with grain.

Bottineau, Dak. (western edge of Turtle Mountain), August 22–30, 1887.—Numerous in large flocks, feeding mostly on fields of unripe oats. Roost in reeds and willows along the creek.

Fort Buford, Dak., September 1–20, 1887.—About 20 were seen in a flock of other Blackbirds early in September, but none were seen after the 10th. They were feeding on grasshoppers and sunflower seeds.

PURPLE GRACKLE (*Quiscalus quiscula*).

Heron Lake, Jackson County, Minn., May 13–22, 1887.—Scarce; found three or four pairs breeding in groves.

Ortonville, Big Stone County, Minn., June 13, 1887.—Common; breeds in the timber along the lake.

Brown's Valley, Traverse County, Minn., June 21–July 8, 1887.—Common. (See Yellow-headed Blackbird.)

Graceville, Big Stone County, Minn., July 11, 1887.—Numerous, (See Yellow-headed Blackbird.)

Flandreau, Moody County, Dak., May 25–31, 1887.—Common.

Harwood, Cass County, Dak., July 12, 1887.—Common.

Grand Forks, Dak., July 19, 1887.—Common.

Pembina, Dak., July 21–August 2, 1887.—A flock of 15 or 20 stay in town and feed around kitchen doors and in the streets; have not seen them out of town,

Devil's Lake, Ramsey County, Dak., August 6–19, 1887.—Common; not numerous.

Bottineau, Dak. (western edge of Turtle Mountain), August 22–30, 1887.—Common in large flocks feeding on grain and bur-oak acorns.

BREWER'S BLACKBIRD (*Scolecophagus cyanocephalus*).

Pembina, Dak., July 21–August 2, 1887.—Saw about 20.

Fort Buford, Dak., September 1–20, 1887.—Numerous; probably 500 stay around the settlement, feeding largely on grasshoppers. They also eat wild sunflower seed (*Helianthus*), and feed along roads, railroads, and around houses. They roost in the brush on the flats.

Tilyou's Ranch, Dawson County, Mont., September 23–October 7, 1887.—Common. Saw a flock of about 40 with a herd of sheep; half of the flock were on the backs of the sheep most of the time.

COWBIRD (*Molothrus ater*).

Round Lake, Nobles County, Minn., May 12, 1887.—Common.

Heron Lake, Jackson County, Minn., May 13–22, 1887.—Numerous.

Ortonville, Big Stone County, Minn., June 13, 1887.—Numerous.

Brown's Valley, Traverse County, Minn., June 21–July 8, 1887.—Numerous.

Flandreau, Moody County, Dak., May 25–31, 1887.—Common.

Fort Sisseton, Marshall County, Dak., June 15–18, 1887.—Numerous.

Harwood, Cass County, Dak., July 12–15, 1887.—Common.

Pembina, Dak., July 21–August 2, 1887.—Common. Have not seen them in fields. A flock of about 20 go with a herd of cows.

Devil's Lake, Ramsey County, Dak., August 6–19, 1887.—Common; in flocks with other Blackbirds, feeding on grain. Generally a few accompany every herd of cattle.

Bottineau, Dak. (western edge of Turtle Mountain), August 22–30, 1887.—Common in flocks with Red-winged Blackbirds.

Fort Buford, Dak., September 1–20, 1887.—A few seen with the Blackbirds early in September; none seen as late at September 20.

BOBOLINK (*Dolichonyx oryzivorous*).

Grand Forks, Dak., July 19, 1887.—Found one flock of about 20 feeding in an oat-field. The males are changing color; some are half brown.

Pembina, Dak., July and August, 1887.—Common; breeds. Seen mostly in flocks feeding on grain.

Devil's Lake, Ramsey County, Dak., August 6–19, 1887.—Common in flocks of from 25 to a less number; nearly always found in a field of unripe oats. The old males are about half black and white, and half yellow. A few young have undeveloped tails.

Bottineau, Dak. (western edge of Turtle Mountain), August 22–30, 1887.—Common in small flocks, feeding on grain.

Flandreau, Moody County Dak., May 25–31, 1887.—Numerous.

Fort Sisseton, Marshall County, Dak., June 15–18, 1887.—Numerous.

Fort Buford, Dak., September, 1887.—One seen September 20.

Round Lake, Nobles County, Minn., May 12, 1887.—Common.

Heron Lake, Jackson County, Minn., May 13–22, 1887.—Numerous.

Ortonville, Big Stone County Minn., June 13, 1887.—Numerous.

Brown's Valley, Traverse County, Minn., June 21–July 8, 1887.—Tolerably common, but not numerous.

FRANKLIN'S GULL (*Larus franklini*).

Devil's Lake, Ramsey County, Dakota, August, 1887.—Numerous. Flocks of from 50 to 500 were seen every day flying over the prairie in the afternoon. They were seldom far from the lake before noon. They feed on grasshoppers, and generally choose a field or level piece of prairie and circle around in a loose flock, coming to within a few feet of the ground (just sweeping the grass tops), but I have not seen them light. August 11 I had a fine opportunity to watch a flock. They came from the lake at 3 p.m. At first a small flock arrived, but at 3.15 it had increased to 300 or 400 birds. The place was a large area of low grassy prairie where grasshoppers were very abundant. The Gulls circled round and round near the grass tops until 3.30 p.m., and then all at once rose and flew away to the lake or to some other feeding ground.

Flandreau, Moody County, May 25–31, 1887.—Saw 5 following the river.

Fort Sisseton, Marshall County, June 15–18, 1887.—Common.

Round Lake, Minn., May 12, 1887.—Common.

Heron Lake, Jackson County, Minn., May 13–22, 1887.—Common; found no nests.

Ortonville, Big Stone County, June 13, 1887.—Flocks are seen occasionally, but do not breed here.

Brown's Valley, Traverse County, June 21–July 8, 1887.—Sometimes numerous and then not seen again for days.

Graceville, Big Stone County, July 11, 1887.—Common on the lakes. I think they must breed at the north end of Lake Traverse, as I saw several when I entered the valley.

MAMMALS.

PANTHER: MOUNTAIN LION (*Felis concolor*).

Montana.—Tilyou's Ranch, Dawson County, September and October, 1887: One is said to have killed a number of sheep lately about 20 miles from here.

Dakota.—Black Hills, November, 1887: Said to be common in the wildest part of the hills. One young was brought into town by a hunter who killed the mother and the other young. I saw it November 2, a few days after it was caught, and think it would have weighed about 8 pounds then. The hunter said that the old one had just killed a large buck Black-tail Deer.

CANADA LYNX (*Lynx canadensis*).

Minnesota.—Elk River, Sherburne County, November, 1887: Rather scarce.

WILDCAT (*Lynx rufus*).

Minnesota.—Elk River, Sherburne County, November, 1887: Quite common here, and said to be numerous in the heavy timber in northern Minnesota.

Dakota.—Turtle Mountain, August, 1887: Said to occur. Deadwood (in Black Hills), October, 1887; a few tracks seen in the snow.

Montana.—Tilyou's Ranch, Dawson County, September and October, 1887: Numerous in the brush, feeding principally on the little Gray Rabbits. A number of hides taken here seem much more red than any I have seen before.

COYOTE; PRAIRIE WOLF (*Canis latrans*).

Minnesota.—Elk River, Sherburne County, 1887: Common, and at times numerous; very troublesome to sheep-raisers. In the fall of 1882 we had 80 sheep running out in the woods, and the wolves killed 22 of them. They were evidently all Coyotes, as no others were seen and there were no other tracks. Only one or two were killed at a time. Sheep can only be kept here by housing at night and keeping in an open pasture during the day. Very few are kept in this vicinity on account of the wolves.

Dakota.—Flandreau, May, 1887: Said to be present. Bottineau (on western border of Turtle Mountain), August, 1887: Said to be numerous.

Montana.—Tilyou's Ranch, Dawson County, September, 1887: Common; hear them bark and howl nearly every morning.

TIMBER WOLF (*Canis occidentalis*).

Minnesota.—Elk River, Sherburne County, 1887: Common here twenty years ago, but not found now except in the heavy timber to the north.

Montana.—Tilyou's Ranch, Dawson County, September and October, 1887: A few are said to occur.

RED FOX (*Vulpes fulvous*).

Minnesota.—Elk River, Sherburne County, 1887: Common.

Dakota.—Fort Sisseton, June, 1887: Said to be common. Devil's Lake, Ramsey County, August, 1887: Common. Black Hills, October, 1887: A few tracks seen in the snow.

Montana.—Tilyou's Ranch, Dawson County, September and October, 1887: Said to be common.

BLACK BEAR (*Ursus americanus*).

Minnesota.—Elk River, Sherburne County, 1887: Formerly common here, as they still are in the timber 50 miles to the northeast, from which region they occasionally ramble through their old haunts in this vicinity. In the past five years there have been two or three special bear migrations in autumn, when they have become common here.

Dakota.—Devil's Lake, Ramsey County, August, 1887: Said to occur. Turtle Mountain, August, 1887: Said to be common. Fort Buford, September, 1887: Occurs, but not so plentifully as formerly. Black Hills, October and November, 1887: Said to be found throughout the hills, and of three kinds—Black, Brown, and Silvertip. Could learn nothing definite about them.

Montana.—Tilyou's Ranch, Dawson County, September and October, 1887: Said to occur, but scarce.

RACCOON (*Procyon lotor*).

Minnesota.—Elk River, Sherburne County, 1887: Common. 'Coons sometimes eat corn in the field, especially before it is ripe.

Dakota.—Harwood, Cass County, July, 1887: Said to be common. Devil's Lake, Ramsey County, August, 1887: Common.

WEASEL (*Putorius ermineus*).

Minnesota.—Elk River, Sherburne County, 1887: Common. In the fifteen years that I have been on a farm we have always kept a large flock of chickens, and only

two have been killed by Weasels, so far as I know. During the past three years weasels have been abundant—more so, I think, than ever before—and all kinds of mice, particularly field mice (*Arvicolæ*) have been unusually scarce.

YELLOW-BELLIED WEASEL (*Putorius longicauda*).

Dakota.—Fort Sisseton, Marshall County, June, 1887: Caught one. It had eaten a large Pocket Gopher all but the head (the gopher was in a trap) and when it came back it took the gopher's place. Pembina, July, 1887: Said to be common. Devil's Lake, Ramsey County, August, 1887: Seems common. Caught two in the holes of Pocket gophers (*T. talpoides*), and think these gophers form a large part of their prey. Their holes are so slightly filled with dirt that the weasel can dig in without trouble. Bottineau, on western edge of Turtle Mountain, August, 1887: Saw one running over the prairie about 9 o'clock in the morning; went into the hole of Richardson's Spermophile. Rapid City, on eastern edge of Black Hills, November, 1887: Have seen a few tracks along creeks, and think they are quite common. Caught one in a trap baited with a prairie dog, and set by creek bank. It is just changing from the brown coat to the white, and is a little more than half white. The change is wholly due to the moult. The brown hairs come out very easily; the white hairs are firm. Many of the brown hairs fell out while skinning the animal. There is no snow on the ground now (November 12), but there was from October 22 to October 28, and a little flurry November 8 that remained but a few hours. The weather is steadily clear, warm days, and freezing nights. The mercury changes from about 28° to 70° F. every twenty-four hours.

MINK (*Lutreola vison*).

Minnesota.—Elk River, Sherburne County, 1887: Rather common and much trapped for fur. In the fall of 1885 one of my neighbors had 13 full-grown chickens killed in two successive nights. I set traps in his barn and caught 2 large Minks that night. Heron Lake, Jackson County, May, 1887: Saw tracks. Ortonville, Big Stone County, June, 1887: Saw some tracks. Brown's Valley, Traverse County, June and July, 1887: Seem to be common.

Dakota.—Fort Sisseton, June, 1887: Present. Harwood, Cass County, July, 1887: Said to be numerous. Grand Forks, July, 1887: Said to occur. Pembina, July and August, 1887: Said to be common. Devil's Lake, Ramsey County, August, 1887: Common. Turtle Mountain, August, 1887: Said to be common. Black Hills, November, 1887: Said to occur.

SKUNK (*Mephitis mephitica*).

Minnesota.—Elk River, Sherburne County, November, 1887: Abundant. I believe Skunks to be beneficial because they feed almost entirely on insects. Heron Lake, Jackson County, May, 1887: Saw one dead. Ortonville, Big Stone County, June, 1887: Seem to be common. Brown's Valley, Traverse County, June and July, 1887: Common.

Dakota.—Fort Sisseton, June, 1887: Common; young half grown. Pembina, July and August, 1887: Common. Flandreau, Moody County, May, 1887: Common. Devil's Lake, Ramsey County, August, 1887: Common. Turtle Mountain, August, 1887: Said to be common. Fort Buford, September, 1887: Common. Rapid City (eastern edge of Black Hills), November, 1887: Caught one in a trap baited with a Prairie Dog; have seen a few holes, but they seem rather scarce.

Montana.—Tilyou's Ranch, Dawson County, September and October, 1887: Common; feed on grasshoppers and bull-berries.

BADGER (*Taxidea americana*).

Minnesota.—Elk River, Sherburne County, 1887: Tolerably common. Heron Lake, Jackson County, May, 1887: Found some holes.

Dakota.—Fort Sisseton, June, 1887: Their holes are everywhere. I believe Badgers have caused the scarcity of small mammals here, as the places where they have dug out Mice and Gopher holes are numerous. I counted forty-five places where one had dug into a Pocket Gopher's hole, and in another locality fifty-eight places. They dig a small hole down until they strike the Gopher's tunnel, and continue the same process at frequent intervals until the tunnel is all cut up. Harwood, Cass County, July, 1887: Said to be common; saw a few holes. Grand Forks, July,

1887: Said to occur. Pembina, July and August, 1887: Common. Devil's Lake, Ramsey County, August, 1887: Common; saw tracks and holes. Bottineau (western border of Turtle Mountain), August, 1887: Said to be common. Rugby Junction, August 31, 1887: Found where a Badger had dug out a Richardson's Spermophile and eaten all but part of its tail. Fort Buford, September, 1887: Said to be common; I saw some tracks.

Montana.—Tilyou's Ranch, Dawson County, September and October, 1887: Common.

OTTER (*Lutra canadensis*).

Minnesota.—Elk River, Sherburne County, 1887: Tolerably common. Heron Lake, Jackson County, May, 1887: Saw where some lived.

Dakota.—Devil's Lake, Ramsey County, August, 1887: Saw tracks of old and young. Turtle Mountain, August, 1887: Said to be common.

Montana.—Tilyou's Ranch, Dawson County, September and October, 1887; Present along the Yellowstone River.

MOOSE (*Alce americanus*).

Minnesota.—Saint Vincent: I am told by an honest and intelligent hunter that some Moose were killed last fall (1886), 15 miles east of Saint Vincent, Minn.

Dakota.—Bottineau: There are said to be some in the Turtle Mountains.

ELK; WAPITI (*Cervus canadensis*).

Minnesota.—Elk River, Sherburne County, 1887: Exterminated; a few old horns and bones remain. They are still found in the woods to the north. Saint Vincent: I am told by an intelligent and honest hunter that some Elk were killed last fall (1886), 15 miles east of Saint Vincent.

Dakota.—Larimore, Grand Forks County, July, 1887: I think I have good authority (in an old hunter) for the statement that two Elk were killed here five years ago. Devil's Lake, Ramsey County, August, 1887: A few said to occur. Bottineau (on western edge of Turtle Mountain), August, 1887: I have found some old Elk bones. Black Hills, November, 1887: Formerly common; a few said to occur still.

Montana.—Tilyou's Ranch, Dawson County, September and October, 1887: Not common; have seen a few tracks, and a few are killed every year.

BLACK-TAILED DEER (*Cariacus macrotis*).

Minnesota.—Saint Vincent: I am told by an honest and intelligent hunter that three were killed last fall (1886), 15 miles east of Saint Vincent.

Dakota.—Pembina, July, 1887: Said to be found 34 miles west of here in the Pembina Mountains. Fort Sisseton: Said to have been present formerly in about equal numbers with the Virginia Deer, but both disappeared about three or four years ago. Devil's Lake, Ramsey County, August, 1887: Said to be a few here, but mostly killed off. Turtle Mountain, August, 1887: I am told that there are a few in the hills, and that they are common on the Mouse River, farther west. Fort Buford, September, 1887: Said to be common among the hills, but I do not consider the authority worth much. Black Hills, October, 1887: The Black-tail is common through the hills, but the White-tail seems to be absent.

Montana.—Tilyou's Ranch, Dawson County, September and October, 1887: Common in the hills and open country; said to be much more easily killed than the Virginia Deer, so consequently are becoming scarce. Said to be common at various places along the stage road from Miles City, Mont., to Deadwood, Dak.

WHITE-TAILED DEER; VIRGINIA DEER (*Cariacus virginianus*).

Minnesota.—Elk River, Sherburne County, November 28, 1887: Now scarce; formerly numerous.

Dakota.—Fort Buford, September, 1887: Said to be common in the brush along the river, but I do not consider the authority worth much. Black Hills, October, 1887: I can find no one who has ever seen this Deer here.

Montana.—Tilyou's Ranch, Dawson County, September and October, 1887: Numerous in the brush along the river.

ANTELOPE (*Antilocapra americana*).

Dakota.—Fort Sisseton: Formerly common here; the last were seen five years ago. Larimore, Grand Forks County: I think I have good authority (an old hunter) for the statement that an antelope was killed at Larimore, Grand Forks County, Dak., two years ago (in 1885). Pembina: Said to be found 34 miles west of here, in the Pembina Mountains. Devil's Lake (northeastern Dakota): A drove of 14 said to have spent last winter (1886–'87) near here. Bottineau (on western edge of Turtle Mountain): Said to be common on the Mouse River, west of here.

Montana.—Tilyou's Ranch, September 23 to October 6, 1887: Common back in the hills and bad-lands. Stage road from Miles City, Custer County, Mont., to Deadwood, Lawrence County, Dak.: Between Boxelder and Willow Creeks I saw a drove of 85, one of 20, and one of 12 (117 in all) in October, 1887.

ROCKY MOUNTAIN SHEEP (*Ovis canadensis*).

Montana.—Tilyou's Ranch, Dawson County, September and October, 1887: Said to be a few in the bad-lands.

Dakota.—Black Hills, November, 1887: Seldom seen; formerly common.

STAR-NOSED MOLE (*Condylura cristata*).

Minnesota.—Elk River, Sherburne County, 1887: Scarce; have not found more than 3 or 4 in fifteen years' residence here.

MOLE (*Scalops aquaticus*).

Minnesota.—Elk River, Sherburne County, November, 1887: I have the skin of the only one I have ever seen here.

SHORT-TAILED SHREW (*Blarina brevicauda*).

Minnesota.—Elk River, Sherburne County, 1887: Common; they often get into cellars and prove troublesome. Ortonville, June, 1887: Numerous all along the little spring brooks; caught one on the high prairie; baited them with cheese, which they took readily.

Dakota.—Harwood, Cass County, July, 1887: Caught one. Pembina, July, 1887: Found one dead.

WATER SHREW (*Neosorex palustris*).

Minnesota.—Elk River, Sherburne County, November 28, 1887: Rather scarce; have always found them living in holes in creek banks; in the spring of 1886 a neighbor caught and gave me one that he found swimming in a small pond of snow water in a hollow near his house.

BLACK-BACKED SHREW (*Sorex* [*forsteri* ?]).

Minnesota.—Elk River, Sherburne County, November, 1887. Quite common, but not so numerous as *S. personatus*. Both species are found in the same localities, and their habits are much the same.

SMALL SHREW (*Sorex* [*personatus* ?]).

Minnesota.—Elk River, Sherburne County, 1887: Abundant; live under logs, leaves, and grass, either in woods, meadows, creek banks, or any wild land. They are always a great pest to settlers who first build in the woods, as they enter barns, houses, and especially cellars, gnawing whatever they can find in the shape of meat, lard, tallow, butter, or anything of the kind. I learned this by experience some fifteen years ago, and have heard the same complaint from others. Cats kill them, but I think generally leave them where killed, for they are often found lying around dead. Brown's Valley, Traverse County, June, 1887: Caught one on the river bank.

Dakota.—Grand Forks, July, 1887: One specimen secured. Devil's Lake, Ramsey County, August, 1887: One found dead in the road. Bottineau (western border

of Turtle Mountain), August, 1887: Caught one under some brush near a creek bank. Black Hills, October, 1887: Saw a few tracks in the snow, and caught 2 at holes in the rocks on top of one of the highest peaks.

HOARY BAT (*Atalapha cinerea*).

Minnesota.—Elk River, 1887: Scarce; I have found but 3 in the last ten years. Ortonville, June, 1887: One evening I saw 8 Hoary Bats rise from the trees and fly up and off towards the prairies. Shot at several, but they were too high. They all rose soon after leaving the trees, and some went almost straight up until out of sight. The exact locality was a small wooded peninsula extending into the lake. Brown's Valley, Traverse County, July 6, 1877: Saw 2 fly from the trees along the Minnesota River.

Dakota.—Pembina, August 3, 1887: Saw one. Devil's Lake, Ramsey County, August 6, 1887: Saw a few.

RED BAT (*Atalapha noveboracensis*).

Dakota.—Devil's Lake, Ramsey County, August, 1887: Common; caught 5 in low trees, and saw others every evening in the woods. Those that I caught were hanging in thick box-elder leaves, from 4 to 15 feet from the ground. The first was in a bush not as high as my head, and I killed it with a stick; the others were higher up.

SILVER-HAIRED BAT (*Vesperugo noctivagans*).

Minnesota.—Elk River, Sherburne County, 1887: Rather more common than the Hoary Bat, but still scarce; roosts under bark on old trees.

Dakota.—Bottineau (on western border of Turtle Mountain): Caught 2 under bark on old trees.

SMALL BROWN BAT (*Vespertilio* [*subulatus?*]).

Minnesota.—Elk River, Sherburne County, November, 1887: Abundant during warm weather.

FLYING SQUIRREL (*Sciuropterus volucella*).

Minnesota.—Elk River, Sherburne County, November, 1887: Abundant.

MINNESOTA GRAY SQUIRREL (*Sciurus carolinensis hypophæus*).

Minnesota.—Elk River, Sherburne County, November, 1887: At present numerous; six months ago scarce. Acorns are an abundant crop this year, and the Squirrels have increased greatly; probably to some extent by immigration, as they are said to have been often seen during the summer on the prairies and crossing fields. They were never so numerous here as at present.

RED SQUIRREL (*Sciurus hudsonius*).

Minnesota.—Elk River, Sherburne County, November, 1887: An abundant resident. Ortonville, Big Stone County, June, 1887: Found none; said to occur, though not common.

Dakota.—Harwood, Cass County, July, 1887: Said to occur here. Grand Forks, July, 1887: Numerous in the woods. Pembina, July and August, 1887: Common in the woods. Bottineau (on western border of Turtle Mountain), August, 1887: Very common wherever there is brush. Black Hills, October and November, 1887: Common all through the pine timber on the hills; they live mostly in holes in the rocks, much the same as *Neotoma;* their principal food seems to be the seeds of pines, the cones of which they store in clefts in rocks and in all manner of sheltered places. I found a hollow pine with 2 or 3 bushels of cones inside of it, and a Red Squirrel in a nest in the middle of them.

EASTERN CHIPMUNK (*Tamias striatus lysteri*).

Minnesota.—Elk River, Sherburne County, 1887: Abundant; they sometimes dig up corn when planted near brush or woods. Ortonville, Big Stone County, June,

1887: Common everywhere in the timber. Brown's Valley, Traverse County, June and July, 1887: Numerous in suitable places on both sides of the valley. The timber in the ravines and along the streams is mostly iron-wood, bass-wood, ash, and box-elder, the seeds of which furnish them an abundance of food; have found but few adults, most of them being about three-fourths grown. Fort Sisseton, June, 1887: Numerous. Harwood, Cass County, July, 1887: Numerous in the woods. Grand Forks, July, 1887: Numerous in the woods. Pembina, July, 1887: Common in the woods. Bottineau (on western border of Turtle Mountain), August, 1887: Quite common, but not so abundant as *T. quadrivittatus.*

ROCKY MOUNTAIN CHIPMUNK (*Tamias quadrivittatus*).

Dakota.—Bottineau (on western border of Turtle Mountain), August, 1887: Common in the brush on top of the Turtle Mountains. Heard one in the brush along the creek where it runs through the prairie. They seem to prefer brush to woods, and generally are found in a thick bunch of willows or hazel brush, and not more than 5 feet from the ground. Have not seen one in a tree. They feed principally on the seeds of choke-cherries, the meats of which is the only food I have found in their pouches. Their call note is a steady churp, churp, churp, like the cry of a Robin when in fear for its young, but with just the slightest husky tone. At first I was sure it was a Robin, but on finding out what it was, could detect a slight difference. The cry is repeated steadily, and about as fast as the chuck, chuck, chuck of *Tamias striatus lysteri*, but not so heavy. When they see or hear you, or become alarmed, the cry changes to a rapid quit, quit, quit, like a Ruffed Grouse when about to fly, but finer and faster. When suddenly frightened they run with a rapid twitter. They are much livelier than *Tamias striatus*, keeping in almost constant motion, especially their long tails, which are switching, jerking, and flirting almost incessantly. When frightened they always run to the ground, but show a good deal of curiosity, and will often be back in the bush in half a minute if you keep quiet. Black Hills, October and November, 1887: Numerous on the hills; more common high up than low down. They live among rocks or brush heaps, and feed largely on rose seeds, a kind of wild rye, snow-berry seeds, and the seeds of a small aster; they also eat grass seeds and seeds of choke-cherries. Fort Buford, September, 1887: Said to occur.

Montana.—Tilyou's Ranch, Dawson County, September and October, 1887: Said to be common, but I have seen only one. Glendive, 1887: Abundant high up on the hills.

STRIPED GOPHER (*Spermophilus tridecemlineatus*).

Minnesota.—Elk River, Sherburne County, 1887: Common on the prairies and openings; in some places numerous. Not found in timber land. They do much damage to crops, principally by digging up seed. They damage corn more than any other crop, sometimes digging up half of the seed in a field, both before and after it comes up. I do not know that they do any serious damage to crops except by taking the seed. Round Lake, Nobles County, May, 1887: Numerous. Heron Lake, Jackson County, May, 1887: Numerous all over the prairies, and especially along the edges of fields, where they dig up the grain. I do not think they do very serious damage, and I know by experience that they are easily caught. Complaints are made of the damage done by them. Ortonville, Big Stone County, June, 1887: Numerous all over the prairie, and only on the prairie. I think one to every acre of ground a small estimate of their numbers. As far as I have observed, they feed on grain, seeds, sorrel roots, strawberries, green leaves, grasshoppers, and other insects. The stomachs examined contained strawberries, red ants, grasshoppers, some other insects, and some green stuff. Caught the smallest adult of the species I have ever seen (total length 268^{mm}, tail 94 and very slender). It is a female, and was nursing. The color is rather lighter than usual. Brown's Valley, Traverse County, June and July, 1887: Numerous all over the prairie; seldom seen on the low ground. Saw the first young July 6; they were about half-grown. This Gopher feeds extensively on the seeds of *Stipa spartea*, which is abundant everywhere on the prairie. In skinning one of them I found a seed of *Stipa spartea* fast in the cheek pouch. The awn was broken off and the seed had turned crosswise, so that the sharp point had penetrated the pouch, which was inflamed and swollen. They eat the tender juicy roots of *Wild Larkspur*, and seem to have dug and eaten it all now. I searched half an hour before finding a specimen, though the top of plants that had been dug and eaten were all around. I have found seeds of knot-grass and puccoon in their pouches. The stomach sent will show many insects and some fruit. June 27 I first noticed that they were cutting wheat that was just heading

out. Each head was cut off at one bite, about five inches from the ground, and remained untouched. Two days later (June 29) I came by the same field and saw that they were still cutting the wheat, and the ground was strewn with the heads. Probably 15 per cent. of the heads had been cut on a strip about 20 feet wide, along the edge of the field, and from a few of the heads the ovules had been eaten. The wheat was just beginning to blossom then. At this time the ovules are about the size of onion seed and slightly milky. The Gophers cut the heads off, examine them, and then try to find a better one, thus eating only a small part of what they destroy. Since very many more of the small watery ovules are required for a feed than in the case of ripe grain it would seem that this is the most destructive period of their ravages. Graceville, Big Stone County, July, 1887: Common; cutting grain. At the edge of a wheat field where one of these Gophers lived the wheat was cut on a semi-circular area about 25 by 45 feet. Selecting a place that seemed a fair average I measured a square yard, on which I counted 31 heads that had been cut down, and 100 that were standing. But few of those cut were eaten, the kernels being about half-grown and watery. Oats and barley were destroyed in the same way.

Dakota.—Flandreau, Moody County, May, 1887: Numerous. Fort Sisseton, Marshall County, June, 1887: Common. Harwood, Cass County, July, 1887: Common; feeds mostly on grain and grasshoppers. Grand Forks, July, 1887: Numerous; working in the grain as at all other places. Pembina, July and August, 1887: Common on open ground and in the fields. Both this species and the Gray Gopher (*S. franklini*) are abundant and of nearly equal numbers, this species probably predominating. On the open prairie they feed largely on grasshoppers, but are more common along the edge of grain-fields, where both species feed almost entirely on grain. I can not see that they show any preference between wheat, oats, and barley. The quantity of grain they destroy is considerable, but evidently less at present than earlier in the season, as it is now full grown and in the dough. Probably they take less now than they will when it becomes ripe enough to store up for future use. Devil's Lake, Ramsey County, August, 1887: Common. Of the three species of *Spermophilus* encountered on this trip the Striped is most numerous, the Gray (*S. franklini*) but little less so, and Richardson's (*S. richardsoni*) seems common. Each species seems to have its special range, indicated by the character of the ground. This species keeps on open ground (prairies, marshes, and fields). *S. franklini* seems to prefer woods, brush, or low, marshy, and weedy places. *S. richardsoni* is the only species I have found on high prairie; generally it was near the edge of a grain-field. The Striped Gopher covers more ground and is more numerous throughout its range than the others. All of the three species are now most numerous at the edges of grain-fields, from which they are carrying grain to store for winter use. But the loss which they cause to the farmers is nearly past, for the greater part of the grain is cut and in the shock and enough is left on the ground to last the Gophers until seed time, and it is easier for them to gather than that in the shock. Bottineau (on western edge of Turtle Mountain), August, 1887: Common on prairies and in fields. Fort Buford, September, 1887: Common, but seldom seen at this season. They are now very fat. At present they live almost entirely on sunflower seeds, though probably also eating cactus seed and seeds of weeds. They are throwing out large piles of dirt from their holes. Have not seen one running about since coming here, though they are common enough, and I had no difficulty in catching them in traps. Have noticed the same thing at Elk River, Minn., where they were seldom seen after September 1. After this they keep very quiet and out of sight as much as possible, never standing upright or making a sound. Have noticed that these animals decay sooner than usual when feeding largely on grasshoppers.

Montana.—Tilyou's Ranch, Dawson County, September and October, 1887: Common; are small and pale. Feed principally on seeds of wild sunflower (*Helianthus*) and grasshoppers, also seeds of the cactus (*Opuntia*). They are very fat.

GRAY GOPHER. (*Spermophilus franklini*).

Minnesota.—Elk River, Sherburne County, November, 1887: Rather scarce. Heron Lake, Jackson County, May, 1887: Found this Gopher here, but not in sufficient numbers to do much harm. Ortonville, Big Stone County, June, 1887: Abundant. A few are scattered over the prairie, but in the timber near the lake, and in the ravines, there are a great many. Of 15 killed, 10 were males and 5 females, but the females have young now and may keep out of sight. The males are quite fat. Their principal food seems to be bass-wood seeds, which are very plentiful. They also eat some green plants and leaves. Shot one while eating a Wood Phœbe that it had just killed. On the prairies they are mostly found near grain-fields or in marshy places. Along the edge of a field of barley where several lived I found where they had been digging little holes, and on examining them

found that at each place they had dug up from three to a dozen kernels of barley that had been buried 1 or 2 inches under ground. Most of it had just sprouted, but that in the field was up 5 or 6 inches high, and there was no meat in the hull. Their cry is a rattling chipper on a high key, much like that of the Striped Gopher (*S. tridecemlineatus*), and I have sometimes been unable to tell them apart. Usually they run low, and go scudding through the grass, but if badly frightened take long, high leaps, exactly like a Gray Squirrel. They seem to like to make their burrows near or under old buildings that are not inhabited, and often live under barns that are in use. Brown's Valley, Traverse County, June and July, 1887: Occasionally found on the prairie, and very numerous all over the valley, even in town. Their food on the prairie seems to consist largely of seeds of *Stipa spartea* and cockle-bur. Wherever the cockle-bur grows the ground is covered with shells of the burs that have had the seeds eaten out. Many of the Gray Gophers live among piles of manure which have been hauled out of town and dumped on the common. They dig in the manure and probably find grain. I have been told that one killed 5 chickens that were feathered out and probably as large as quail. The woman who told me saw the Gopher kill one of them. I have seen one within 15 feet of an open door, and it did not seem at all afraid. Many live under houses. I saw the first young one out of the hole June 30, and some more July 6. They were about half grown.

Dakota.—Pembina, July and August, 1887: Common in brush, prairie meadows, and fields. Caught one on the prairie and found in its stomach much wheat, some grasshoppers, and the remains of several young mice (*Hesperomys michiganensis*). Fort Sisseton, June, 1887: Common. Harwood, Cass County, July 1887: Common; not numerous. Grand Forks, July, 1887: Scarce. They bend the grain over, instead of biting it off like the Striped Gopher. Flandreau, Moody County, May, 1887: Scarce. Devil's Lake, Ramsey County, August, 1887: Common; seems to prefer woods or low marshy and weedy land. Bottineau (on western border of Turtle Mountain), August, 1887: Evidently scarce; saw none alive, bnt found one that a hawk had partly eaten.

Richardson's Gopher (*Spermophilus richardsoni*).

Dakota.—Devil's Lake, Ramsey County, August, 1887: Tolerably common. Found on the high prairie, generally along the edge of grain-fields. Killed one as it ran from under a shock of oats. Its pouches were stuffed full of oats, 269 kernels in all. Bottineau, August, 1887: More numerous than any other Gopher, averaging about 1 Gopher to every 2 acres of prairie. They feed on grain in the fields, and largely on seeds of pigweed (*Chenopodium album* and *boscianum*), both kinds of which are abundant. They do not seem to be collected around fields more than on the open prairie. Have never found them in the brush or on low or weedy ground. From sunrise to 9 o'clock in the morning they may be seen running or sitting up all over the prairie, even in the edge of town. After 9 a. m. they retire to their burrows and are seldom seen. They are the least suspicious and have the most curiosity of any of the Spermophiles known to me. When they run, their tails flap up and down like a Woodchuck's, and when sitting up they shake their tails every few seconds. Their holes are large, with a pile of earth like a Pocket Gopher's hill at the entrance. Of 13 specimens killed here, but 1 was a female. Much of their excrement is scattered about near and in the entrance of most of their burrows, which is something I have never seen near the holes of other Spermophiles. Rugby Junction, 1887: Numerous.

Prairie Dog (*Cynomys ludovicianus*).

Montana.—Tilyou's Ranch, Dawson County, September and October, 1887: Eight miles from here there is a colony of about 6, and 5 miles down the river there is another colony of 100 or less. They feed on grass and many kinds of weeds. I visited a Prairie Dog colony on the east side of the Yellowstone River, 21 miles from Fort Buford. The colony occupies a level prairie about 1 square mile in extent, and just above flood level. There are probably 2,000 holes, and not 100 dogs. But few of the holes are used, and some are closed up. I think they do not live in a hole longer than one year. In most cases the dirt is thrown out of the holes all around, instead of in a pile on one side. It then forms a cone like a volcano around the opening, the rim varying in height from 10 inches to less. The quantity of dirt thrown out varies much; at some places I estimated that there was 2 cubic yards of it; at other holes there was none. The earth is very hard at the edges of some holes, evidently having been packed while wet, and forms a sharp ring around the

hole. The holes run down at an angle never far from 45°, and seem to go straight on at that pitch for about 8 or 10 feet at least. A piece of dirt will roll down them and can be heard rattling a long way down. The holes are usually smaller at the opening than farther down; the entrances are slightly flattened, so that the two diameters are not alike. Following are measurements in inches of the longest and shortest diameters of several burrows, taken near the opening: 4 by 5, 4 by 5, 4 by 3½, 4 by 3½. Many holes have been dug larger by Skunks or Badgers. I have been told that Prairie Dogs never leave any excrement near the holes, but I find it scattered all around, and most numerous near the holes, some even down in the holes. The animals are very shy. When they see you they run to the nearest hole, and then sit up like a Gopher and watch until you approach within 40 rods; then they dodge down the hole, or sometimes crawl part of the way in and continue to watch until you are quite close, but if shot then and killed ever so dead they will slide down beyond all reach. I tried to dig them out, but after digging down 3 or 4 feet in the hard clay could see away down the hole, and gave it up. It still took more than a bushel of loose dirt to fill the hole below, so that dirt would not slide down. When they are sitting up at a distance watching you they keep up a chippering that is almost exactly like the barking of a very small dog, but is faster. While barking they keep their tails flapping up and down very fast, and also when running and when they start down a hole. The motion is the same as that of Richardson's Gopher (*S. richardsoni*), which they resemble much in all their actions. They feed mostly on a short, fine grass (buffalo grass) that grows all over the prairie. They dig it up and seem to eat the bottom part, for the ground is covered in places with the leaves and roots. In the excrement I find traces of nearly every plant which grows near, especially of *Artemisia frigida*, knot-grass, and a small aster that is full of seeds. They are very fat. I cooked one and ate part of it. It was not cooked very tender, but was perfectly sweet and free from any strong taste; was much like the flesh of a mallard duck. There is not the least unpleasant smell about them. There was a dead horse in the dog-town, which I was told broke its leg by stepping into a Prairie Dog hole when running. I am told that a man about 40 miles from here has a machine for forcing sulphur smoke down the holes, and that he kills many by smoking them out. Glendive, October, 1887: On a prairie about 2 miles north of town there are a few Prairie Dogs. I have killed 6, and there are probably as many remaining. There are many unused holes extending over about 1 square mile of land (perhaps 1,000 holes), and the dogs are said to have been numerous there last summer, but from some cause have disappeared. The people here think that the cold winter killed them off. Some persons say that a crust of ice covered the ground for a long time, and the dogs starved because they could not get to the ground for food. Last year was unusually dry, and vegetation, always scant here, was nearly all dried up. Then followed a very cold, stormy winter. Nearly all the cattle and sheep died, and probably the Prairie Dogs were likewise affected by the weather. In this colony there are four places, far apart, where from 2 to 4 dogs live together, each group occupying 3 or 4 holes, but having 1 hole which seems to be home, and into which they generally run when frightened. When they run into their holes I have not known them to come out within an hour, and sometimes they do not come out again for half a day. Their food seems to consist principally of the roots and the lower part of the stalk of the fine, short prairie grass, but nearly all of the surrounding plants are eaten more or less. Do they hibernate? The people here say they do not, but come out to feed on every warm day all winter. Along the stage road from Miles City to the Little Missouri dog-towns were frequently seen, but few of the holes seem to be occupied.

Dakota.—Fort Buford: Not present in this immediate vicinity, but there is said to be a large town about 60 miles northwest from here, on the Milk River. Rapid City, November, 1887: One of the earliest settlers here, a Mr. Chase, says that when he came to this place, in 1877, Prairie Dogs were numerous where the town of Rapid City now is, as well as over most of the surrounding prairie. Little flat mounds, indicating where the holes were, still remain, but most of the Prairie Dogs have disappeared. About 2 miles east of town there is a colony of about 100, occupying probably 40 acres of land. I should think there were 200 holes, and every one seems to be used. It is on a level prairie near, and about 12 feet above, Rapid Creek. This prairie is fenced in at present and used for a horse pasture, though part of the ground has been plowed and a crop of millet was raised on it this year. About one-fourth of the Prairie Dog holes are in the field of millet stubble. The ground that has not been plowed is covered with short, fine grass, but near the holes this grass has been dug up and eaten until killed out over a space 2 rods wide or less, around most of the holes. This space, where there is no grass, has grown up thick with knot-grass, which they do not seem to dig up. I think the stomachs sent will show that knot-grass seed now forms a large part of their food. Probably to it they owe much of their fat.

It takes little imagination to make this seem like farming, for the Prairie Dogs keep digging up the grass around the outside of their little farms all summer, and so enlarging their field of grain for fall and winter use.

The knot-grass grows all along roads and old fields. Probably it is *Polygonum aviculare* or a variety.

Several Prairie Dogs often run into the same hole. I have counted as many as six going into one hole. The last one generally stays out and barks until approached almost within shooting distance, and sometimes until close enough for a shot. I approached one by walking slowly and whistling until within about 20 feet, and then shot it dead, but could never charm another.

If they see a person 40 rods away they all run and get into or very near their holes and bark; as you come nearer they get lower down in the holes, until almost out of sight, but keep barking and shaking their tails until they think the danger is too near, then, with a parting shake of the tail, down they go, and they are not likely to appear again for several hours. By creeping very low I have got near enough to shoot some through the head with large shot, and if killed very dead, and I could get hold of it before it slid or kicked down the hole too far, it was my dog; if not, it was lost.

They seem to pay no attention to horses feeding among their holes, but run all around them. I have found two stone arrowheads among the holes, and so conclude that the Indians liked Prairie Dogs.

When they see anything suspicious at a distance they get on the highest mounds, and, stretching as tall as possible, watch it. Now and then one will come up to the perpendicular with a kind of jump, evidently to try and get a little higher, and at the same time utter a peculiar cry, a kind of long "chur-r-r-r-r." This is the only sound I have ever heard them make beside barking. If a Red Squirrel was as large as a Prairie Dog its bark would not be very different—that is, when a Red Squirrel barks the fastest and most excitedly.

They do not throw the dirt out of their holes in one pile in front of the hole, as Woodchucks and most animals do, but it is built up in a ring around the hole, forming a cone with sometimes quite sharp edges. The cone varies according to the amount of dirt thrown out, and is generally 10 or 12 inches high. It is sometimes a steep rim, and is sometimes wide and flat. The mouth of the holes are nearly always "bell muzzled," or flaring from the bottom to the top of the cone, and in most of the holes you can plainly see where the dogs have shaped it, while the earth was soft and muddy, by pressing it back with their noses, leaving the little round prints of their noses in the hard clay close together, and perhaps a hundred or more in the sides of one doorway. Eyes dark brown (the iris). The animals are now very fat, but show no signs of hibernating.

WOODCHUCK; GROUND HOG; MARMOT (*Arctomys monax*).

Minnesota and eastern Dakota.—Occurs in the Red River Valley from Pembina southward, but is rare. In Sherburne County, in eastern Minnesota, it is rather common.

YELLOW-BELLIED WOODCHUCK (*Arctomys flaviventer*).

Dakota.—Occurs in the Black Hills, but was not known from the region about Fort Buford.

BEAVER (*Castor canadensis*).

Dakota.—Fort Buford, September, 1887: Said to be found along the Missouri River. Black Hills, October and November, 1887: Formerly common here; a few said to be still found in places far back from the settlements.

Montana.—Tilyou's Ranch, Dawson County, September, 1887: Quite common along the river; have seen some tracks.

HOUSE RAT; NORWAY RAT (*Mus decumanus*).

Minnesota.—Brown's Valley, Traverse County, June and July, 1887: Abundant.

Dakota.—Grand Forks, July, 1887: Said to have been found here only recently. Pembina, July and August, 1887: Does not occur. Devil's Lake, Ramsey County, August, 1887: Does not occur. Fort Buford, September, 1887: Common; caught a very large one in my room, and heard them every night.

HOUSE MOUSE (*Mus musculus*).

Minnesota.—Elk River, Sherburne County: The House Mouse is common about our buildings. Ten years ago, when the place was new and surrounded by timber,

the White-footed Mouse was the common house Mouse (1886). Brown's Valley, Traverse County, June and July, 1887: Abundant.

Dakota.—Fort Sisseton, June, 1887: Common. Grand Forks, July, 1887: Common. Pembina, July and August, 1887: Common. Devil's Lake, Ramsey County, August, 1887: Common.

WOOD RAT; BRUSH RAT (*Neotoma cinerea*).

Dakota.—Black Hills, October and November, 1887: Common among the rocks high up. They live in caves, cracks, and holes under the rocks. Their principal food seems to be the seeds from the pine cones. Large piles of gnawed cones are scattered around their holes.

WHITE-FOOTED MOUSE (*Hesperomys leucopus*).

Minnesota.—Elk River, Sherburne County, 1887: Numerous everywhere.

WESTERN WHITE-FOOTED MOUSE (*Hesperomys leucopus sonoriensis*).

Minnesota.—Brown's Valley, Traverse County, June 21 to July 8, 1887: Most numerous on the east side of Lake Traverse.

Dakota.—Pembina, July 21 to August 2, 1887: Common, and with one exception found only in the woods. Devil's Lake, Ramsey County, August 6 to 19, 1887: Common in woods and brush. Bottineau (on western edge of Turtle Mountain), August 22 to 30, 1887: Numerous in the brush. Fort Buford, September 1 to 20, 1887: Abundant in all brush, and common on prairie and hills. Evidently feeds extensively on the seed of cactus (*Opuntia missouriensis*) and the seed of wild sunflower (*Helianthus rigidus*). Deadwood, in Black Hills, October 24 to 31, 1887: Common on the tops of the highest hills. Fort Sisseton, Marshall County, June 15 to 18, 1887: Apparently scarce; probably because of the abundance of Badgers. Rapid City (on eastern edge of Black Hills), November 16, 1887: Quite common among the rocks on the hills and around fields on the prairie. The color of the adults is paler than any seen before.

Montana.—Tilyou's Ranch, Dawson County, September 23 to October 6, 1887: Common in brush and on hills.

MICHIGAN MOUSE (*Hesperomys michiganensis*).

Minnesota.—Brown's Valley, Traverse County, June 21 to July 8, 1887: Common on the high prairie in the town of Traverse, on the Dakota side of the valley. Found them in the same holes with the Grasshopper Mouse (*Onychomys leucogaster*) in the Indian mounds.

Dakota.—Harwood, Cass County, July 14, 1887: Numerous all through the fields and meadows; cuts down much wheat and other grain. Flandreau, Moody County, May 25 to 31, 1887: Found on ground a little higher than that inhabited by the Meadow Mice (*Arvicola riparius*). Caught one on top of a high hill. Pembina, July 21 to August 2, 1887: This *Hesperomys*, which is common on the prairies here, seems to be about the only Mouse of economic importance. It lives near the grain fields, and cuts down a small quantity near the edges. It cuts some grasses on dry ground for the seed, but is not numerous enough to be of great importance. I think it eats the seed of pennycress (*Thlaspi arvense*) which has become so thick that in some fields nothing else can grow. Some fields are abandoned to it, and it is more or less in all of them. While this species inhabits the prairies and open ground, the White-footed Mouse lives in the woods. Bottineau (on western edge of Turtle Mountain), August 22 to 30, 1887: Caught one under a wheat shock on the prairie that I believe is this species. It is very different from from the *H. leucopus* found here in the brush, the principal difference being in the darker gray color, slenderer build, and much slenderer tail.

GRASSHOPPER MOUSE (*Onychomys leucogaster*).

Minnesota.—Brown's Valley, Traverse County, June and July, 1887: Numerous on the flats near town and common on the high prairies west of the valley; not found on the east side. They live in holes on the top of Indian mounds, in sides of banks, and in holes under débris among brush. They seem fond of cheese and fried cakes, but of their other food I learned only by dissection. They begin moving

early in the evening, and I shot one while running through the weeds about 8 o'clock in the morning.

Dakota.—Devil's Lake, Ramsey County, August, 1887: Found one dead on a road. Bottineau (on western edge of Turtle Mountain), August, 1887: Did not secure it, but a farmer described it accurately and said he had found a few. Fort Buford, September, 1887: Common on the hills and prairies; not found in the brush; easily caught in any kind of trap baited with cheese or cake. They live in holes which they dig or steal; I think they generally occupy those of the Yellow Arvicola (*Arvicola pallidus*), for wherever I have set traps at a collection of *Arvicolas*' holes I have caught some *Onychomys*, but evidently they dig holes for themselves, for I have caught them at holes where fresh dirt was thrown out every night. I suppose this species does not hibernate, for none of its near relatives do, though one that I caught was very fat. The fat, however, was not so much under the skin as it is in most, if not all, hibernating mammals. One which I kept in confinement was not full grown when caught. From the first it did not show the least fear. It took food from my fingers when first offered, and never attempted to bite. If not disturbed or very hungry it sleeps all day, and when waked up gapes, stretches, and blinks sometime before he gets fully awake, but is then lively for a time, though he does not seem to like the light, and if it is bright keeps winking. In the evening he becomes lively and tries to get out, jumping and scratching at the sides of his cage, and biting the wires of the front, but he never gnaws, and though he has been a week in a thin cigar box there is not a tooth-mark in it. Sometimes he becomes crazy in his efforts to get out nights, and jumps about with all his might; but usually, unless hungry, he is quiet and intelligent. He will come to the front of his cage at once if the wires are rattled or scratched and look for food. If a fly gets inside he is pretty sure to see it, and seldom fails to catch it. He will not eat raw meat, but the way he takes hold of grasshoppers and flies shows that they are not new to him. He ate 16 crickets, 11 grasshoppers, 1 spider, a black bug, and a big fly one forenoon. When very hungry he will eat weed seed or the leaves and stems of knot-grass and pigweed, but he has not been hungry enough for this many times since I have had him. He will also eat a little cheese and fried cake when hungry, but not much, and evidently does not relish it. His favorite food is crickets; he will not eat anything else while there is a cricket in his box. Next to crickets he will take grasshoppers or flies, but does not seem to care so much for beetles, though he will eat any kind that I have yet offered him, principally a small black beetle that lives under sticks and stones; he also eats lady-bugs. I have found only one potato bug since I have had him, and he seemed to relish that, as he ate it all but the wings, shell, and legs. He always begins at the head of an insect, holding it in his hands while he eats. A grasshopper will just nicely sit on its tail while he eats its head, with a hand on each shoulder; but the hopper is bound to kick, and if a large one, makes him much trouble, sometimes tipping him over; but he never lets go or stops eating until the head is off; then he eats his way to the tail. The wings and legs fall off as he eats the body out of them, and if he has plenty to eat they are left; but if hungry, and the supply is short, he will eat the legs afterward. He eats spiders, soft bugs, and dragon flies. He killed and ate a small frog when hungry, but would not touch one after eating all the hoppers he wanted. Next to insects he will take raw meat, fat or lean. He is very fond of brains. The only insects offered him which he would not eat were ants, and a few in his box make him almost crazy. If a dozen grasshoppers or crickets are put in his box alive he will kill them all by biting off their heads before he eats any. The same day that I caught him I dropped a dead White-footed Mouse (*Hesperomys leucopus*) into his box. He pounced upon it like a cat, caught it by the side of the head near the ear, and began biting with all the ferocity of a coon dog. I could hear the bones crack, and when he let go and seemed satisfied that it was dead I took it out and found quite a hole broken through the skull just below the petrous bone. His teeth must have penetrated far into the brain. I put it back and *Onychomys* began at once to gnaw through and pull off strips of flesh from the neck, shoulders, and skull, but did not get at the brain. He ate both of its eyes. The savage disposition shown in his manner of attack, and his promptness to seize it, would indicate a habit of killing mice. September 22.—At 7.43 a. m. I gave him 12 crickets and 1 spider. He had eaten them all in seven minutes. At 8 a. m. he ate 3 grasshoppers; at 10, 1 big fly; at 10.15, 4 grasshoppers and 4 crickets, and at 11.45, 4 grasshoppers and a black bug; total, 30 large insects in four hours. Did not have time to catch any more for him. September 25.—At 6.45 a. m. he ate 1 fly and 2 black beetles; at 7.30, 1 grasshopper and 18 crickets; at 10, 2 grasshoppers and 2 flies; at 12 m., 3 flies, 2 hoppers, and 7 crickets; at 1.30 p. m., 6 big blue flies; at 2, 3 big flies; at 2.30, 3 grasshoppers; and at 6, 3 crickets; total, 2 beetles, 8 grasshoppers, 15 flies, and 28 crickets, or in all, 53 large insects in less than twelve hours. He would have eaten more if he had had them.

September 28.—Put a small *Hesperomys* in his box and he served it in the same way that he did the other one; also gave him a Song Sparrow that I had killed; he bit it through the head and ate part of it. I gave him a black hornet, which he took and ate greedily, but the tail seemed to bother him, and he evidently got stung on the nose, but did not seem to mind it much. He is very fond of cream. September 30.—Gave *Onychomys* a common gray moth, which he ate and seemed to relish. October 3.—He ate a piece of another mouse of his own kind, and tried to eat it before it was skinned. He has settled one thing for me; that a squeaking cry which I heard evenings at Brown's Valley, and once or twice at Devil's Lake, was made by this species. He has made the same sound several times. It is something like the cry of a Flying Squirrel. Of 4 skinned, I was able to save but 1 without the loss of a patch of hair from the belly. Though the weather was cool, they would not keep more than six hours without the hair loosening over the belly. Most of those captured at Brown's Valley show one or more bare spots. I have noticed the same thing in Striped Gophers (*S. tridecemlineatus*) which had been feeding on grasshoppers. Probably insect food causes this tendency to early decomposition. The excrement of this species is easily known by the remains of insects it contains.

Montana.—Tilyou's Ranch, Dawson County, September and October, 1887: Common on prairies and hills; probably lives in the holes of some other mice.

RED-BACKED MOUSE (*Evotomys gapperi*).

Minnesota.—Elk River, Sherburne County, November, 1887: Common. Brown's Valley, Traverse County, June and July, 1887: Very common. They live mostly in the banks of the Minnesota River, which is a narrow creek with high, steep, brushy banks. I found some in brushy ravines, and one on the prairie.

Dakota.—Fort Sisseton, Marshall County, June, 1887: Caught 2. Seem common in the brush land. Pembina, July and August, 1887: Common in the woods. Bottineau, August, 1887: Common; probably numerous along the creek. Caught one under a shock of wheat on the prairie. Deadwood, Lawrence County, October, 1887: Caught one on the mountain top, and saw some tracks in the soft snow.

MEADOW MOUSE (*Arvicola riparius*).

Minnesota.—Elk River, Sherburne County, November 28, 1887: At times very numerous, and again scarce; at present date unusually numerous. The only way that I can account for this is that when the water is high in the brooks and on the meadows, they are forced to leave their holes, and are destroyed by their natural enemies, while in the dry seasons they burrow in the brook banks and meadows. This year is very dry. When numerous they destroy much grain if left long in the shock, especially corn left standing all winter, sometimes eating it half up. They have killed a few apple trees for us by gnawing the bark around the bottom in winter when the snow was deep. Heron Lake, Jackson County, May 13–22, 1887: Caught one. Ortonville, Big Stone County, June 4–14, 1887: Probably common, although I found but few. Brown's Valley, Traverse County, June 21–July 8, 1887: Common in all low places.

Dakota.—Fort Sisseton, Marshall County, June 15–18, 1887: Common. Flandreau, Moody County, May 25–31, 1887: Found near a small slough on the flats of the Sioux River. Their paths extended in all directions through the grass, and were strewn with the grass which they had cut down for food, but I could find no holes or nests, and think they live under the dead and fallen grass which is thick in places. Bottineau (on western edge of Turtle Mountain), August 22–30, 1887: Common; not numerous. Fort Buford, September 1–20, 1887: Probably common where there are marshes, but there are none near here. Found one dead in the road, and saw one under brush and weeds in a ravine.

PALLID MEADOW MOUSE (*Arvicola pallidus*).

Dakota.—Fort Buford, September, 1887: The Pallid *Arvicola* seems to be common here, and shows a decided preference for the north side of steep hills. I have not found them on the south, southeast, or southwest side. The only reason I can suggest for this distribution is that the twilight (their favorite hour) is longer on the north side. The hills where I have found them are all steepest on the north side, which may have some effect, though there seems to be no difference in the vegetation on different sides. Like other *Arvicolæ* they have many holes, and probably live in families or colonies, although I have not caught more than one at a group of holes; but from the difficulty in catching them this does not signify anything (have caught only 4). Where there is grass or weeds their holes are connected by

beaten paths in the same manner as those of *Arvicola austerus*, but in many places they are in bare clay. Their food seems to consist largely of the flowers of certain plants, judging from the remains of flowers scattered around the holes and from the contents of their stomachs and excrement. When these plants grow near there are usually pieces of stems and blossoms of *Liatris graminifolia* and *Artemisia frigida* lying about, but many other plants and grasses seem to be eaten. They feed largely on the seeds of *Eurotia lanata*. I found a place near their holes where something had dug down to a partly eaten bulb of *Liatris graminifolia*. Probably these bulbs form a part of their diet, as is the case with *Arvicola austerus*. I placed corn, oats, cactus seeds, and seeds of weeds around their holes, but they remained untouched. The same was true of bread and cheese, and fried cake was seldom eaten. They seem suspicious of traps, and evidently leave their holes when traps are set near them. I have caught several *Onychomys leucogaster* and *Hesperomys leucopus sonoriensis* at their holes, and think these species either drive out the *Arvicolæ* or else inhabit the old holes.

PRAIRIE MEADOW MOUSE (*Arvicola austerus*).

Dakota.—Rapid City (eastern edge of Black Hills), November 16, 1887: They are numerous in a few places, always in brush or weed patches on low prairies. They seem to live in colonies, and dig an immense number of holes, throwing out quite large piles of dirt.

NORTHERN PRAIRIE MEADOW MOUSE (*Arvicola austerus minor*).

Minnesota.—Brown's Valley, Traverse County, June 21–July 8, 1887: Common, probably on both sides, but I took it only on the Dakota side. Found where they had dug and eaten many wild onions (*Allium striatum*) and the bulbous root of a plant of the composite family, which I can not name. Ortonville, Big Stone County, June 6–13, 1887: Common on the high prairie; lives in holes, usually in small elevations of some kind, as old ant-hills or a bog. Elk River, Sherburne County: Common on high ground; never found on the low meadows with *Arvicola riparius*.

Dakota.—Devil's Lake, Ramsey County, August 6–19, 1887: Very scarce; caught 2. Bottineau (western edge of Turtle Mountain), August 22–30, 1887: Quite common; feeds largely on the bulbous roots of *Liatris graminifolia*, which is abundant all over the prairie.

LEMMING MOUSE; COOPER'S MOUSE (*Synaptomys cooperi*).

Minnesota.—Elk River, Sherburne County: Rather rare. Usually found on low meadows or near a brook; have never caught any in traps. Of the 7 or 8 specimens which I have taken, the first was dug out from under a tamarack stump on a wet marsh; 2 I caught in my hands while making hay, both on low meadows and near a brook. In the winter of 1886–'87 I took 3 or 4 from the cats, but do not know where they caught them.

MUSKRAT (*Fiber zibethicus*).

Minnesota.—Elk River, Sherburne County, 1887: Numerous; live in holes in banks of creeks and rivers, and in houses which they build in ponds and lakes. They eat fresh-water mussels, small turtles, and lily roots. The mussels eaten are both the thin-shelled kind of the mud-bottomed lakes and the heavy-shelled of rivers (*Unio*). Some trappers use mussels for bait. The turtle eaten by Muskrats is a small bright-colored terrapin, probably *Chrysemys picta*. Three or four years ago I took from a Muskrat house a small turtle with three of its legs and its tail eaten off and the shell gnawed. It was still alive. The lily roots eaten are *Nymphæa tuberosa* and *Nuphar advena*. They form a large part of the food of Muskrats in winter when the ponds are frozen.

Minnesota and Dakota.—Red River Valley: Common at all points visited, from the south end of Big Stone Lake north to Pembina.

Dakota.—Flandreau, Moody County, May, 1887: Common. Fort Sisseton, Marshall County, June, 1887: Common. Devil's Lake, Ramsey County, August, 1887: Common. Rapid City, Pennington County, November, 1887: Common along the creeks.

Montana.—Tilyou's Ranch, Dawson County, September and October, 1887: Found holes and excrement of a few along a creek.

LITTLE GRAY RABBIT (*Lepus sylvaticus*).

Minnesota.—Elk River, Sherburne County, November, 1887: Common in and around the towns; rather scarce in the country. I do not think they were here eight years ago. Heron Lake, Jackson County, May, 1887: Common. Ortonville, Big Stone County, June, 1887: Common in the brush and around town. Brown's Valley, Traverse County, June and July, 1887: Common in the valley and ravines.

Dakota.—Fort Sisseton, June, 1887: Common. Fort Buford, September, 1887: Common in the brush of the river flats and ravines. It follows paths through the brush, but does not keep well-beaten trails like those of the Varying Hare (*L. americanus*). Rapid City, Pennington County, November, 1887: Quite common.

Montana.—Tilyou's Ranch, Dawson County, September, 1887: Numerous in the brush.

VARYING HARE (*Lepus americanus*).

Minnesota.—Elk River, Sherburne County, November, 1887: Common.

Dakota.—Grand Forks, July, 1887: Said to occur. Pembina, July and August, 1887: Common. Bottineau (in western border of Turtle Mountain), August, 1887: Evidently numerous. The hazel brush on the hills is all cut off at about 2 feet from the ground, and the ground is strewn with excrement of this species and that of *L. campestris,* which is about four times as large.

JACK RABBIT (*Lepus campestris*).

Minnesota.—Heron Lake, Jackson County, May, 1887: Said to occur. Ortonville, Big Stone County, June, 1887: Said to be quite plentiful here, but I have failed to find them. Brown's Valley, Traverse County, June and July, 1887: Common on both sides of the valley.

Dakota.—Flandreau, Moody County, May, 1887: Saw two; one was young and about the size of the Little Gray Rabbit (*L. sylvaticus*). Fort Sisseton, June, 1887: Said to be common; saw one, but could not get within 60 rods of it. They keep on the open prairie and are as wild as deer. The people here think the only way they can be captured is with greyhounds. They have been killed off until they are now very scarce. Grand Forks, July, 1887: Said to occur. Fort Buford: Common on the prairie. Pembina, July and August, 1887: Said to be common; saw but one. Devil's Lake, Ramsey County, August, 1887: Seem to be common. Bottineau (western edge of Turtle Mountain), August, 1887: Common. Rapid City, Pennington County, November, 1887: Common. Shot one that I scared from an excavation it had made in hard clay in the midst of a Prairie Dog town where there was not a weed or blade of grass for protection. Still, it resembled its surroundings so closely as it squatted in the hole with its ears laid flat and its back level with the ground that I walked close to it without noticing it till it jumped and ran. The excavation measured 5 inches in depth, 6 in width, and 12 in length. This is the fourth Jack Rabbit I have scared out of just such a hole. I think they sit in the same place every day if not disturbed, but have not known one to return after being frightened.

Montana.—Tilyou's Ranch, Dawson County, September and October, 1887: Common; eat cactus berries. Stage road from Miles City to Deadwood, October, 1887: Common all along; saw a few.

EASTERN PORCUPINE; BLACK-HAIRED PORCUPINE (*Erethizon dorsatus*).

Minnesota.—Elk River, Sherburne County, 1887: I have unquestionable authority for the killing of two in this county. They are said to be common in the evergreen timber 50 miles north.

WESTERN PORCUPINE; YELLOW-HAIRED PORCUPINE (*Erethizon epixanthus*).

Montana.—Tilyou's Ranch, Dawson County, September, 1887: Common in the undergrowth on the river flats, feeding principally on bull-berry leaves and berries, and cottonwood bark. I found one under a brush heap. The small limbs with berries had been cut off from many of the bull-berry bushes near the place. Its stomach was full of bull-berry leaves and berries, and contained nothing else. It was very fat. I crawled under the brush heap and poked it with a stick. When annoyed this way it would strike with its tail in all directions, up, down, and sideways, striking hard; its tail would thump on the ground as loud as a blow from a man's fist. After it

had been striking with and switching its tail I found a number of quills scattered over the ground for a distance of 2 feet from it. They were probably knocked off from the tail when it struck the ground or sticks. It did not offer to run, but curled its nose down and under, arched its back, and struck with its tail at everything which touched it. I found another under some thick, low bull-berry bushes. It was an adult female, very fat, and weighed 19 pounds. Its actions resembled those of the first, except that when disturbed it ran to another thick bunch of bushes about 10 rods away and when approached ran back again. Its stomach was full of bull-berry leaves and berries and cottonwood bark. Both of these individuals had a strong smell, which I think came from their food, for the contents of their stomachs smelled the same, ands tronger. The people here kill them at sight, on the supposition that they destroy the timber by gnawing the bark from the green trees, but I have not found a tree that they have injured, and I have spent much time in the woods here; have tramped all over a large part of the river bottoms where Porcupines are most common, but found no sign of their work except where they had cut branches from the bull-berry bushes to get at the leaves and berries. Their eyes are small; iris brown; pupil large and blue, so the eye looks blue.

JUMPING MOUSE (*Zapus hudsonius*).

Minnesota.—Elk River, Sherburne County, 1887: Common.

Dakota.—Flandreau, Moody County, May, 1887: Saw one. Harwood, Cass County, July, 1887: Found two in a nest near a wheat-field; the nest was made of fine grass, and concealed under some fallen grass of last year; the entrance was on the side; the nest was placed in a small depression scooped in the ground. Pembina, July and August, 1887: Common in weedy places. Devil's Lake, Ramsey County, August, 1887: Common near brush and in weedy places. Fort Buford, September, 1887: One found on a nest of fine grass, under fallen weeds and brush; it was an adult male and exceedingly fat.

YELLOW POCKET MOUSE (*Cricetodipus flavus*).

Minnesota.—Brown's Valley, Traverse County, June and July, 1887: Caught one July 1 on the prairie on the Dakota side, about 80 rods west of the Minnesota line. It was about two-thirds grown, and its cheek pouches were full of the seeds of knot-grass (*Polygonum aviculare*), among which it seemed to be feeding. Saw another in a marsh on the flats, but could not get it.

Dakota.—Fort Buford, September, 1887: Caught one here.

Montana.—Tilyou's Ranch, Dawson County, September and October, 1887: Common; live in holes which they dig in weed patches on the prairie; they come out to feed about sundown and at daylight; they feed on small seeds of weeds, mostly pigweed, but will not take bait. They are fond of the seed of knot-grass (*Polygonum aviculare*), but pigweed seed is their favorite food, and they are generally found in or near a patch of it; I have killed them with their pouches packed full of it. I caught 6 in my hands. Their holes are smaller than those of any of the Mice, and usually are in clusters. Skunks dig out their holes and probably are their worst enemy.

POCKET RAT; KANGAROO RAT (*Dipodomys agilis*).

Montana.—Glendive, Dawson County, October, 1887: They live in holes in a mound of earth that has been thrown out of a railroad cut; their holes are about the size of those made by the Striped Gopher, but are very different in appearance—more like those of the House Rat. They are connected by well-beaten paths. Most of them enter the ground in nearly a horizontal direction. Usually a little fresh earth is thrown out every night. A few of the holes are stopped up through the day, like a Pocket Gopher's hole, but they seem to be opened every night, when more dirt is thrown out. At these there is always the largest pile of dirt. I opened one, set a trap in it, and caught an adult *Dipodomys*. At some of the holes they have thrown out much of a kind of fine, short, prickly grass, but whether it was taken in the holes for a nest or for food I could not tell. Their food seems to consist principally of the seeds of grasses and fine weeds. They seem to be strictly nocturnal, for though I have kept traps set night and day, I have not caught one in the early evening or near daylight in the morning. One evening I remained at the place until too dark to see a rat at my feet, but I did not see one, nor was one in any of the traps when I left. They are not fat at all, and by this I judge they do not hibernate. Have not found anything in their pouches, but some had grass seed in their mouths when caught. They are easily caught in steel traps set in the dirt

at the mouth of a hole. Just back of their shoulders there is a small elongated bare spot, which shows plainly from the wrong side of the skin, and seems to be composed of little round glands or dots.

POCKET GOPHER (*Geomys bursarius*).

Minnesota.—Elk River, Sherburne County, November, 1887: Abundant; most numerous on the lightest and sandiest soil, and the poorer the soil the more they dig. They are considered a great pest. They do not destroy much grain by eating it, though sometimes they get into a shock of wheat and eat the heads of a few bundles. When their holes run through a hill of potatoes, they always clean out the hill. Sometimes they do noticeable damage in a patch of potatoes; I have seen where one Gopher had eaten the potatoes out of about a dozen hills, never more. But the greatest damage they do is in covering small grain and grass with the earth which they throw from their holes; the damage done in this way is often considerable. I once counted the hills thrown up by three Gophers twelve days after a rain. The number of fresh hills was, respectively, 28, 35, and 40. As near as I could judge without measurement, the hills averaged about 6 quarts of dirt each, and each covered about 1 square foot of ground. Pocket Gophers work mostly by night. They continue throwing up hills all the time a crop is growing. One Gopher to the acre will cover a large area of grain, but probably they will not average one to the acre except where most numerous.

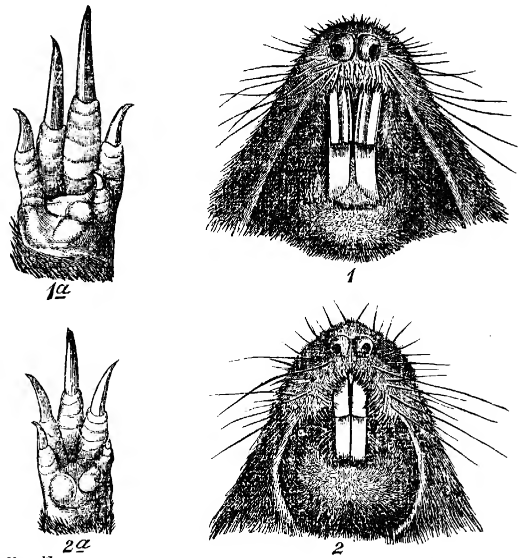

FIG. 1. Pocket Gopher (*Geomys bursarius*). 1. Face, showing grooved upper incisors and opening of external cheek pouches. 1*a*. Fore foot.

FIG. 2. Gray Pouched Gopher (*Thomomys talpoides*). 2. Face, showing plane upper incisors and open-opening of external cheek pouches. 2*a*. Fore foot.

[Drawings from alcoholic specimens.]

In fields where the soil is shallow the continuous throwing up of the dirt below the soil is said to injure the producing qualities of the land, but I do not feel certain that it is so. I think it probable that their plowing the land over and over for ages past has much to do with its fertility, at any rate with the depth of soil. They have spent their lives in preparing the ground for man, and now he spends his time in trying to get rid of them. But this is not hard to do, nor does it take much time, for of all animals they are the most easily trapped, as they live almost entirely under the ground, and extend their holes slowly. When all in a field have been caught, others do not get in it again soon. In the spring many of them leave their holes and travel above ground; these are probably the males. Sometimes they leave one hole and start another, but usually I think one Gopher stays in its hole all summer. I have

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POCKET GOPHER (GEOMYS BURSARIUS).

never found more than one in one set of holes. They lay up large stores of food for winter, mostly roots and stems of weeds cut into short pieces. Round Lake, Nobles County, May, 1887: Numerous. Heron Lake, May, 1887: Present, but not in sufficient numbers to do much harm. Ortonville, June, 1887: Common in the hollows and on the low ground; rare on the high prairie. Brown's Valley, Traverse County, June and July, 1887: Common on both sides; keep mostly on low ground, very numerous in the valley.

Dakota.—Flandreau, Moody County, May, 1887: Numerous. Fort Sisseton, June, 1887: Common. Grand Forks, July, 1887: Quite common along the river bank and railroads; a few in the fields. When in grain-fields they run long, crooked tunnels about 2 inches below the surface, and coming out at short intervals, cut down the grain and carry it into their holes. Many of the holes for a distance of several feet are packed full of grain stalks, and seem to be used only to store grain in. Most of the grain is cut into pieces, about 1 or 2 inches long, but some whole stalks are drawn in. Their object seems to be to fill the holes with a supply of food to be eaten at leisure, but much more grain is drawn into the holes than can be eaten while fresh, for on examining old holes I found them full of moldy stalks. I am not sure what part they eat, for they leave a great deal of all parts. I think they eat stalks and all, but mostly the heads.

Dakota.—Devil's Lake, Ramsey County, August, 1887: Common. The principal damage they do is in meadows. Harwood, Cass County, July, 1887: Common along the railroads, and occasionally in the woods near the river bank.

GRAY POUCHED GOPHER (*Thomomys talpoides*).

Minnesota.—Saint Vincent, August 31, 1887: Common.

Dakota.—Pembina, July and August, 1887: Common everywhere. Occurs on the Manitoba side of the boundary, and on the Minnesota side of the valley. As a rule this species avoids cultivated fields. I have found but one place where it was living in fields of grain, and this one had cut down the grain near its hole and carried it below ground, stalks and all, just as *Geomys* does. Though abundant here, this was the only instance where I found it in a field. They seem to prefer the wild plants on the prairies, especially *Psoralea argophylla*, a species of wild clover with long pulpy roots, that grows abundantly all over the prairies, except in low grassy places, where neither it nor the Gophers are found. These roots have so strong a smell that it is imparted to the Gophers, so that they smell as strong as the roots. Specimens caught in the woods lack the smell entirely. The other food which I have found them eating was the leaves, stems, and roots of various weeds and grasses. They are most numerous along the weedy ridges, while *Geomys* prefers low ground and marshes. *Thomomys* are much easier to catch than *Geomys*, and do not fill their holes with dirt so far down. I can dig any of them open with my fingers. *Thomomys* are not half as large as *Geomys*. Their manner of throwing up hills differs from that of *Geomys* in several ways: (1) The single hills average about half as large as those of *Geomys*; (2) they generally form a cluster or group, instead of a line, and consequently are less progressive (a cluster of hills where a Gopher has evidently worked all summer seldom extends more than 5 or 6 rods); (3) they often open the hole and throw out dirt several times in the same place, making irregular hills of various sizes. Sometimes, though not generally, a Gopher throws out the dirt through the same hole every night (filling the opening through the day), until it has formed a pile of a bushel or more; then throws up another at a long distance from the first. The farthest apart of connected hills that I have measured was 27 feet, generally less. This seems to be their way of traveling. No small hills are found near the very large ones, but these seem to be connected by a straight hole which continues in a certain direction. Following are the dimensions of some of the large hills: 4 by 4 feet, and 10 inches high; 4 by 5 feet, and 9 inches high; 3 by 3 feet, and 7 inches high; 4 by 5 feet, and 6 inches high. They must breed earlier than *Geomys* or get their growth sooner, for their young are very nearly full-grown now (August 3), while the young of *Geomys* are about half grown. The following statement shows the number of developed teats in the adult females examined; all had been nursed this season: 3–4, 4–5, 4–5, 4–5, 4–6, 5–5, 5–5, 5–6, 5–6, 6–6, 5–7. Devil's Lake, Ramsey County, August, 1887: Common, but not so abundant as at Pembina. Here, as at Pembina, they avoid the marshes, where only grass grows, and cultivated fields. One group of their hills in a marsh and two in a stubble-field are the only ones I have found, although I have been over many fields and marshes, and find them common at the edges. In one field that was broken this summer (about 40 acres) I could not find a hill, though many Gophers must have been there before it was plowed. Evidently their holes run so near the surface that a plow destroys them and the Gophers leave. The principal damage done by *Geomys* is in meadows, and

if *Thomomys* lives neither in meadows or fields, which is the case so far as I have observed, they are practically harmless. Their food here seems to include nearly every plant that they find, but they show a decided preference for leguminous plants, especially for the roots of *Psoralea argophylla* and *Glycyrrhiza lepidata.* They also eat the roots of asters and milkweeds. Probably their greatest enemy is *Putorius longicauda*, two of which I caught in their burrows. Bottineau (on western border of Turtle Mountain), August, 1887: Numerous (as common as at Pembina). Feed largely on the roots of *Psoralea argophylla*, which is abundant. Found places where three of them were at work in a stubble-field, and one of them had only thrown up one hill; so they must have come there since the grain was cut. Fort Buford, September, 1887: Common, ranging from the water level in the ravines to the tops of the highest hills; often found where there is scarcely any vegetation. Deadwood (in northern part of Black Hills), October, 1887: One has thrown up hills near here, but I failed to catch it. Rapid City (on eastern edge of Black Hills), November, 1887: Common. For the first time I find them doing enough damage to be worth noticing. They range from the lowest ground to the tops of the highest hills, but are most numerous on the creek flats, which might be called low prairie or high meadow land. This is valuable because it is the only land here that will produce anything worth raising, and most of it is under cultivation or else fenced in to protect the wild grass, which grows thick and makes an excellent quality of hay, probably equal to timothy. It is in these wild, dry meadows that *Thomomys* are most numerous and damaging. The principal damage they do is occasioned by covering up the grass with earth from their holes, and perhaps to some extent by cutting off the roots. In one meadow of about 20 acres there were 10 Gophers, as nearly as I could estimate by their work, and they have thrown out on an average about 20 hills each since the hay was cut. Each of these hills covers from 1 to 4 square feet of ground and grass. I have found the works of but one in cultivated fields here, and that was near the edge.

Montana.—Tilyou's Ranch, Dawson County, September and October, 1887: Common everywhere. Stage road from Miles City, Mont., to Deadwood, Dak., October, 1887: Hills common all the way.

DESCRIPTION OF LOCALITIES VISITED BY VERNON BAILEY DURING THE SUMMER OF 1887.

Heron Lake, Jackson County, Minn.

Heron Lake, in Jackson County, Minn., is a very irregular body of water, about 14 miles in extreme length, and varying from a narrow channel to 3 miles in width. It is very shallow, being nowhere more than 6 feet deep. The bottom is clay. Along the southwest side, and occupying a large space between the north and south divisions of the lake, is a great field of reeds (*Phragmites communis*). In some places the reeds are tall and dense; in others scattering and interspersed with coarse grasses, flags, and rushes, all growing in water from 6 inches to 2 feet deep. At some seasons the marsh is nearly dry. Its area is about equal to that of the lake. Several creeks flow into the lake; its outlet is the Des Moines River.

The surrounding country is gently undulating prairie, which contains numerous shallow sloughs. The soil is all clay. Along the east shore of the lake are some scattered groves of native timber. The largest, some 8 or 10 acres in area, is mostly box elder, hackberry, elm, and plum; some of the trees are 2 feet in diameter. The rest of the prairie is bare of timber, except the groves of cottonwood that have been planted.

Brown's Valley, along the boundary between Minnesota and Dakota (partly in Traverse County, Minn., and partly in Roberts County, Dak.).

Brown's Valley is a continuation of the depression occupied by Big Stone and Traverse Lakes, which are now about 4 miles apart, but which evidently at one time were one lake, or more likely a river. The valley is about 2 miles wide (as are the lakes throughout their length), and but a few feet above the water level. Water is said to flow from Traverse to Big Stone during spring freshets. By late measurements the water level is said to be 9 feet higher in Traverse than Big Stone. The lowest parts of the valley flats near the lakes are covered with coarse grass and reeds, and in the middle, where higher, with grass, weeds, and thickets of snow-berry bushes.

The Minnesota River is a small, rapid creek, entering the flats from the west about 2 miles from the south end of Lake Traverse. It flows through a deep,

crooked valley in the prairie, which contains much brush and small timber and occasional grassy flats. Along its course through the flats its banks support a thick growth of brush and small trees, mostly willows, box elder, and plum.

The prairie which bounds the lakes and flats rises as a steep bank probably more than 200 feet above the level of the lakes, and is cut into by numerous ravines which are washed out by water and contain more or less timber and brush. There are no sloughs. The soil is mostly gravelly clay. Along the edge of the prairie are numerous Indian mounds and earth works.

My observations were made principally on the prairie on both sides of the valley, and along the brushy and wooded valley of the Minnesota River, west of Lake Traverse; also in a wooded ravine on the east side, 1 mile from the south end of Lake Traverse.

Flandreau, Moody County, Dak.

The country about Flandreau is all prairie, except along the river bottoms, where there are strips and thickets of brush with a few trees. There are no sloughs or marshes except a few old river courses on the flats. The surface is quite hilly near the river flats, but back from these is mostly level. The soil is a gravelly clay.

Ortonville, Big Stone County, Minn.

Ortonville is situated on the east side and near the south end of Big Stone Lake. The lake is about 35 miles long and from 1 to 2 wide. The shore is mostly steep and stony, but in some places is low and bordered with coarse grass, rushes, and reeds. From the shore of the lake the ground slopes back gradually a little way, and then rises in a line of very steep, high hills, or rather banks, for they rise only to the level of the prairie, which is about 150 feet above the lake.

There is a growth of small timber and brush on the low ground near the lake, on the points of land extending into it, on the islands, and in the numerous ravines which extend back into the high ground. But few of the trees are large. The principal kinds are basswood, box-elder, elm, and ash, with a few bur-oaks. The surrounding country is all prairie, slightly rolling and with some small marshes, but I have not seen any sloughs. The soil is mostly clay; it is very stony, with granite and lime-rock bowlders. Springs of very cold, pure water are numerous all along the foot of the hills and in the ravines, where they form little brooks. The land is rich, and the prairie is covered with a thick growth of grasses and other plants, many of which are decidedly western. Species of the pulse family abound, especially *Astragalus caryocarpus*.

Fort Sisseton, Marshall County, Dak.

The country about Fort Sisseton is much broken, often rising in high hills, with numerous large sloughs which are strongly alkaline. Generally the slopes are long and gradual, but in some places, especially near the sloughs, they are steep and bank-like. There is no drainage system, not a creek or river for 35 or 40 miles. The soil is gravelly clay, very productive, and vegetation is generally rank.

Patches of thick brush and scrubby trees, mostly oak, bass, and ash, occur along the borders of the sloughs, and in some places over the hills. Occasionally there is a large oak, elm, or cottonwood, but large timber is scarce.

Harwood, Cass County, Dak.

The land about Harwood is level prairie, unbroken, except by the timber along the streams, which is continuous and from one-half to 1 mile in width. This timber is mostly elm, box-elder, willow, and oak, and many of the trees are large and thrifty. The river flows between high, steep banks. The open land is all under cultivation. The fields of wheat, oats, and barley form one almost continuous body and yield large crops.

Animal life shows more of the characteristics of timber than of prairie land. Some species, not being crowded into small groves as on the prairie generally, are not so numerous, while others occur which are not met with in any of the localities previously visited.

Grand Forks, Grand Forks County, Dak.

The region about Grand Forks is a level prairie, about 25 feet above low water in the Red River. There is a strip of timber (bur-oak, cottonwood, basswood, elm,

ash, and box-elder predominate) about half a mile wide along the river. During the high water the river rises nearly to the level of the prairie, but never overflows. The water is slightly alkaline. The soil is clay, very stiff. The prairie is mostly under cultivation, the principal crops being wheat, oats, barley, and grass; they yield heavily.

Animals that inhabit timber land seem to be most numerous, those of the prairie being rather scarce; probably owing to the low, damp ground, where water stands after heavy rains. Possibly alkali affects the distribution of mammals, but I can find no proof of it.

Pembina, Pembina County, Dak.

The level of the prairie at Pembina is about 25 feet above low water in the Red River. The surface is everywhere undulating, with about 18 inches difference in the level. On the prairie the ridges and hollows are quite regular, and are plainly marked by a difference in vegetation, grass only growing in the hollows and various plants and weeds on the ridges. Along the river the land is uneven and ridged by water. The soil is black, rich, and productive; subsoil very sticky, and when wet and worked, very hard clay. A rich growth of vegetation covers the prairie. A line of timber extends along each river, varying in width from 2 miles to less, and in most places full of thick underbrush. The principal trees are elm, box-elder, willow, cottonwood, and a few oak and basswood. The principal undergrowth consists of hazel (full of nuts), June-berry, choke-cherry (full of fruit), high-bush cranberry (full of fruit), black haws (fruit not ripe yet), thorn bush (full of fruit), raspberries, and other brush. The timber is generally smaller and more brushy than at Grand Forks. On the east side of the Red River there is very little except poplar and willow brush, and this, interspersed with dry, grassy marshes, extends about 4 miles east of the river, and is only separated from the great timber region of Minnesota by about 7 miles of prairie. I have seen but one slough (4 miles west of Pembina), and it is small and shallow, but surrounded by a large tract of coarse grass. The crops are generally good. I think wheat will be ready to cut about August 8 or 10, if not sooner.

My observations have mostly been made in the timber and brush along the Pembina River, over the prairie west and north for a distance of 4 or 5 miles, and in the brush and meadow land on the east side of the Red River.

The weather since I have been here has been clear, with pleasant days and cool nights. There was a light frost July 22, but no damage was noticeable.

Devil's Lake, Ramsey County, Dak.

Devil's Lake is a large body of water in Ramsey and Benson Counties, northeast Dakota. The surface of the surrounding country is variable. There are hills and gently rolling prairies, interspersed with marshes, and near the lake are large areas of level, sandy, and salt-incrusted land, with scant vegetation. The lake is very crooked and irregular in outline, with sandy or reedy shores. All the points, peninsulas, and islands, besides some strips along shore, are covered with heavy timber and thick brush. There are some solid bodies of forest, many square miles in extent. The timber is largely bur-oak, box-elder, and elm. Among the brush there is an abundance of June-berry bushes, choke-cherries, wild plums, wild currants, and raspberries.

The soil is clayey and productive. Crops generally are good. No streams flow out of the lake. The water is clear, but slightly salty, and a crust of salty matter is deposited on stones or whatever the water washes along shore, and on the sand that is near the level of the lake. The surrounding prairie is about half under cultivation, the principal crops being wheat and oats, probably three-fourths wheat and one-fourth oats.

My observations have been made along the lake shore, in the timber, and back over the prairie for a distance of 5 or 6 miles, including as different physical features as possible. In physical features, plants, and animals there is a strong resemblance between this and the Fort Sisseton region.

Bottineau, Bottineau County, Dak.

The little town of Bottineau is on a level prairie, about 2 miles from the Turtle Mountains, which rise with a slope of about a mile to a height of probably 1,000 feet above the surrounding prairie. They form a plateau that is moderately hilly on top and cut through by some deep ravines. The hills are mostly covered with thick brush, and in places, especially in the ravines, there is straggling timber, mostly pop-

lar, box-elder, elm, and bur-oak. Among the brush is an abundance of June-berry bushes, choke-cherries, wild red cherries, and high-bush cranberries, the last four now loaded with ripe fruit. The bur-oaks are full of acorns, down to bushes four feet high.

There are said to be many lakes farther back in the hills than I have been. A small creek comes down through a deep ravine in the mountains, and flows near the town in a southwest direction across the prairie. Along its banks are thick brush and a few trees. The prairie is quite level, and covered with short, fine grass. There are no sloughs or lakes near here.

Crops are good, and consist principally of wheat and oats.

Fort Buford, Buford County, Dak.

The fort is situated near the left bank of the Missouri River, opposite the mouth of the Yellowstone. It is on a level prairie—the second river flat—which is about a mile wide and 4 or 5 long, running parallel to the river, and averaging about 20 feet above the bank. Extending most of the way between this and the river is another flat, on a level with and forming the river bank, which is about 15 feet above low water. This lower flat is covered with a dense growth of brush and trees. The principal trees are cotton- wood, box-elder, and black ash; the brush is largely willow, some thorn, rose, choke-cherry, and a thorny bush called bull bush or bull-berry bush, which is now loaded with fruit—a small red berry of pleasant taste.* This flat varies from a half mile in width to less, and the brush is so thick and large as to be almost impenetrable, except as roads are cut through it.

From the farther side of the prairie (back from the river) steep, high hills rise to a height of probably 1,000 feet above the river. Deep ravines, with steep or perpendicular sides and full of brush (largely choke-cherry and bull-berry), cut through these hills and through the prairie, running down to the river. In the bottom of each ravine is generally a small brook which goes dry between rains.

The hills are mostly covered with a very scattering growth of fine grass and small weeds, but in places are bare clay or soft sandstone, without vegetation and in curious shapes from the wearing away of the softer parts, leaving them with steep or projecting sides.

In the valleys between the hills (not the ravines) and on the prairie there is a good grass for pasturage, some sage brush, various weeds, and cacti, some of which are of interest as forming food for birds and mammals—particularly a wild sunflower (*Helianthis rigidus*).

The first frost was recorded September 15.

Tilyou's Ranch, Dawson County, Mont.

Tilyou's Ranch is situated on the Yellowstone River, 26 miles from Fort Buford, Dak. The river valley is about 5 miles wide, generally level. It is inclosed by high hills, scantily covered with vegetation; on the east side the hills are very steep, rough, and bare. Good grass grows along the creeks and on low places; elsewhere vegetation is stunted and scarce. The river flats are covered with willow and bull-berry brush and cottonwood timber. The general features and animal life are much the same as at Fort Buford.

During my stay of thirteen days the weather has been clear, dry, and pleasant, with cool nights and warm days.

DESCRIPTION OF THE BAD LANDS OF DAKOTA AND MONTANA, OBSERVED FROM FORT BUFORD TO MILES CITY.

This region has the appearance of having been a great plain, slightly rolling, and deposited to a depth of at least 1,000 feet in quite regular layers, from 4 to 50 feet thick, principally of soft, gray sandstone (sometimes rusted or colored), and a peculiar gritless, hard, but when wet sticky and slippery, clay called "gumbo."

The change from a level, sloping plain to the curiously-formed and most intensely uneven surface now presented is the result of erosion. The rivers have cut through the soft sandstone and clay, until at present they are from 600 to 1,000 feet below the original level of the plain. This gives the branches and small side streams a steep descent to the main rivers, and they have cut down deep gorges through the sandstone and "gumbo," which are of sufficient solidity to retain, in this very dry climate, very steep or quite perpendicular sides, on which little or nothing grows.

* This proves to be the Buffalo berry (*Shepherdia argentia*).

Back from the level valley of the Yellowstone River, which is generally 4 or 5 miles wide, the land rises in what would be a great wall, but it is all cut up into bare peaks and humps, which farther back have flat tops, showing the plain level, and which increase in size until far back from the valley they run together and form the plain. The sides of these peaks and spurs show the different strata through which the water has cut, and as these strata are of different degrees of hardness they resist erosion unequally, producing the curious shapes which always excite the wonder of the visitor. The effect is heightened by different color combinations, the sandstone being light gray, the "gumbo" brown, the strips of coal black, and a kind of shelly stone pink. Viewed from a distance the bad-lands remind one of some old closely-built city, with towers, castles, and forts. If there was as much rain here as in the Mississippi Valley these hills would be smoothly rounded and covered with luxuriant vegetation.

In the valleys and on the plain there is a rather scattering growth of short, fine grass and sage brush, but on the hills below the plain level there is very little vegetation, at a distance apparently none. Sage brush and a few other small plants grow on some of the most sloping sides, but more of them are perfectly bare. In some places red cedars, very short and scrubby, grow in the nooks and along the edges of the hills.

Deadwood, Lawrence County, Dak.

The town of Deadwood, in the northern part of the Black Hills, is situated in a deep, narrow valley or gorge, through which runs a rapid creek of red water that looks exactly like blood. It takes its color from a red clay through which it runs. The hills rise high and steep from the valley, probably to a height of 2,000 feet from their base, and are covered with pine, spruce, and brush. The timber is scattering, and much of it has been cut. The hills are stony, and at the tops of most of them are ledges or peaks of rock, with many cracks, crevices, and holes. Wherever there is soil over the rock vegetation is abundant. Grasses, wild rye, golden-rod, asters, snow-berries, a small rose bush, and numerous other plants and shrubs cover the hills. There are also birch, hazel, and a kind of scrubby oak. My field work at Deadwood was done on the mountains within a few miles from the town.

Rapid City, Pennington County, Dak.

Rapid City, on the eastern edge of the Black Hills, is in the Rapid Creek valley, just where it leaves the pine-covered mountains and enters the more level and treeless prairie region. The hills to the west are high, steep, and rocky, covered with jack and yellow pine, and in some of the ravines there are a few scrubby iron-wood and oak trees and brush. The prairie may be divided into low, level, and fertile creek valleys (where the farms are), and high, dry, and unproductive table-lands and hills covered with short grass. The descent is steep and the creeks very rapid. The soil is good, but there is not enough rain during the season to make farming a success, except on the lowest land, unless by irrigation.

The weather from November 1 to 16 was steadily clear, with warm days and freezing nights.

NOTES ON THE DEPREDATIONS OF BLACKBIRDS AND GOPHERS IN NORTHERN IOWA AND SOUTHERN MINNESOTA IN THE FALL OF 1887.

By Dr. A. K. FISHER, *Assistant Ornithologist.*

BLACKBIRDS.

At Round Lake, Minn., most of the Blackbirds had gone by the end of September, but their work was plainly visible in every corn-field. Mr. D. W. Lounsbury pointed out the results of their depredations in his own fields, and devoted considerable time to driving around to neighboring farms that a number of fields over a comparatively large area might be examined. All had been more or less damaged. The loss was estimated at from 5 to 50 per cent. of the crop.

One farmer made the statement that out of all corn husked in a previous year there were few cobs which contained more than an inch or two of grain at the base, the rest having been removed by the birds.

The time when most of the damage is done is when the kernels are soft and milky. The birds readily tear through the husk and reach the grain. The heavier ears, which by their weight take a horizontal position, suffer most, as the birds can gain a better footing than on the vertical ones.

Certain portions of a field, or fields in certain localities, suffer more than others. Sides of fields facing sloughs, or fields surrounded by them, and portions away from farm buildings suffer more severely than those favorably situated. Little damage is done to corn after the kernels harden. A few fragments were found in the stomachs of birds captured in the field about the 1st of October, but the larger part of the contents of the stomachs consisted of the seeds of the Fox-tail grass (*Setaria*).

Oats and wheat were said to be eaten by Blackbirds, but the greater damage done to these grains is by Gophers.

The chief reason why the Blackbirds, which are mainly Red-wings and Yellow-heads (*Agelaius phœniceus* and *Xanthocephalus xanthocephalus*), are so troublesome in this locality is that so small a proportion of land is planted to corn compared with the vast amount of surrounding prairie. The rank vegetation bordering the lakes and sloughs on the unimproved land furnishes safe retreat for nesting and roosting, from which the birds make frequent inroads upon the neighboring isolated corn-fields.

The same state of affairs existed at Storm Lake, Iowa, some years ago, before corn was so extensively raised as at present. Now the loss is very little felt on account of the large area under cultivation.

In endeavoring to lessen the damage done by the Blackbirds some farmers shoot large numbers as they go to and from the fields, and the frequent firing is thought to frighten a good many away. Others use poison alone or in connection with fire-arms.

Strychnine is the favorite poison. It is placed in water with a quantity of green corn cut from the cob; the mixture is allowed to soak for some hours. A few kernels of this poisoned grain are placed on the ears that have been damaged by the birds in the fields. When the birds return they are supposed to eat the loose grain which they find. One farmer who had tried this method, and who visited their roosting places, reported a number of dead birds.

GOPHERS.

Although the damage done by Blackbirds is very great, and the total value of the grain destroyed by them reaches a high figure, it is doubtful whether it exceeds in amount the losses occasioned by Gophers.

In southwestern Minnesota and northern Iowa there are three species of Gophers, namely, the Gray Gopher (*Spermophilus franklini*), the Striped Gopher (*Spermophilus tridecemlineatus*), and the Pocket Gopher (*Geomys bursarius*), the last species being by far the most destructive.

The Gray and Striped Gophers are more or less alike in habits, living a considerable portion of the time above ground and feeding on the same substances. Where abundant, as they are in many parts

of the West, they destroy large quantities of corn, wheat, oats, and the seeds of flax. They also feed to some extent on seeds of wild plants, even when grain is plenty. A Striped Gopher shot at Heron Lake near a field of wheat stubble had its pouches full of the seeds of the ragweed (*Ambrosia artemisiæfolia*).

In view of the fact that large numbers of these animals are shot and handled it is surprisingt hat they are not used as an article of food. Their flesh is as sweet and delicate as that of the arboreal Squirrels, which are held in high esteem as a game dish in many parts of the East. The farmers agree that they ought to be good to eat, but it was impossible to learn of any one who had tried them. The Pouched Gopher, whose habits are entirely different from those of the Striped or Gray Gophers, lives in extensive underground galleries, rarely comes to the surface, and commits depredations rivaling in extent those of the Blackbirds.

Both at Storm Lake, Iowa, and Round Lake, Minn., complaints were made of the damage done by Pocket Gophers to fruit and shade trees by their gnawing off the roots, which soon destroyed the tree.

Mr. Lounsbury showed me an apple tree, fully 6 inches in diameter, all the roots of which had been cut off by Pocket Gophers. He has lost upwards of 100 apple trees in the past few years by these destructive rodents. Vegetable gardens also suffer severely from their depredations. In some potato fields in exposed situations the inroads are so great that it is a question whether the crop is worth gathering. When a field is badly affected one year the farmer the following spring strives to place the new plant as far from the old as possible, thereby securing a good crop before the Gophers discover the field. Pocket Gophers follow along the rows of hills, commencing when the potatoes are not more than half an inch in diameter and not stopping until the crop is harvested. One farmer alleges that he found in the store-house of a Pocket Gopher at least two quarts of potatoes about the size of cherries.

Considerable damage is done to meadows by the loose dirt brought to the surface from the galleries and deposited in numerous mounds, thereby killing the grass thus covered. Numbers of Pocket Gophers are trapped, but more are killed by placing poisoned potatoes in the galleries.

The losses occasioned by the destruction of crops by Blackbirds and Gophers were so severe that the supervisors of Nobles County, Minn., early in 1887, appropriated $1,500 to pay bounties at the following rates: Blackbirds, 10 cents a dozen before July 1, 6 cents after that date; Striped and Gray Gophers, 3 cents; Pocket Gophers, 5 cents. As is usually the case with bounties little good was accomplished, and no appreciable diminution in the numbers was observed.

REPORT OF THE CHIEF OF THE BUREAU OF ANIMAL INDUSTRY.

SIR: I have the honor to transmit herewith my report, which contains a statement of the more important work accomplished by the Bureau of Animal Industry during the past year. For many interesting details of this work, and for the reports of the Agents and Inspectors, I must refer you to the Fourth Annual Report of the Bureau of Animal Industry.

D. E. SALMON,
Chief of the Bureau of Animal Industry.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

OPERATIONS OF THE BUREAU.

The work for extirpating contagious pleuro-pneumonia, and for preventing its spread into uninfected States and Territories, has recently been the most important business of the Bureau of Animal Industry, and because of its urgent nature and the evident intention of the law has received more attention than any of the other duties which have come before it. The other lines of work mentioned in the act establishing the Bureau have, however, been kept in hand, and very much valuable work has been done. There has been continual co-operation with the authorities of the Western States and Territories to prevent as far as possible the losses produced by the disease generally known as Texas fever. There has been constant investigation of reported outbreaks of cattle disease in various States, to determine the nature of maladies supposed to be dangerous, and the proper methods to be employed in their prevention and treatment. There has been a scientific investigation carried on regarding the cause and the means of preventing our worst contagious diseases, and there has been an investigation made into the condition of different branches of the animal industry in the various States. In addition to the work just mentioned, there has been the clerical work of the Bureau—the correspondence, the record of the work, the supervision of accounts, the preparation of reports, etc., which, during the past year, has required a great amount of labor.

In attempting to present this work with considerable detail, I will first refer to the measures adopted for the suppression of pleuro-pneumonia, and then more briefly recount the most important part of what has been done in the other directions.

PLEURO-PNEUMONIA.

At the time my last report was submitted the contagious pleuro-pneumonia, or European lung plague of cattle, existed not only in the plague spots of the Eastern States, where its presence has been recognized for years, but to an alarming extent in Chicago, one of the greatest live-stock centers of the country. The knowledge that this deadly contagion had fixed itself so far in the interior, where there was so much danger of its being scattered in many directions by the movement of cattle, caused apprehension and alarm among the cattle owners and business men of all the Western States and Territories. The introduction of cattle, not only from Cook County, but from the whole State of Illinois, was prohibited by the State authorities in many instances. Thus there was at once a most serious and widespread interruption of traffic and disturbance of values, in addition to the losses from the disease.

When the outbreak at Chicago was discovered, and for some months afterwards, both national and State laws applicable to its eradication were imperfect. The appropriation for the Bureau of Animal Industry for the year ending June 30, 1887, authorized the purchase of diseased animals whenever it was necessary to prevent the spread of pleuro-pneumonia from one State into another; but as the statute then in force in Illinois required the slaughter of animals affected with this disease without compensation, it did not appear necessary that they should be purchased by the General Government. The work of the Department was therefore confined to an investigation of the extent of the disease and the maintenance of a guard over the infected distillery stables and over one infected farm upon which were found exposed about 250 head of cattle.

The inspection made by the Department veterinarians soon showed that the contagion had been disseminated quite extensively by diseased cattle which had pastured upon the vacant lots and commons about the city, and there mingled with many milch cows which had been allowed to run at large.

The appropriation act approved March 3, 1887, not only increased the sum to be expended by the Bureau of Animal Industry from $100,000 to $500,000, but gave authority to purchase both diseased and exposed cattle, and made $100,000 immediately available. The Chief of the Bureau was at once directed to proceed to Illinois and reach some understanding, if possible, with the governor and live-stock commission, by which the work in that State might be made efficient and the disease eradicated without further delay. At a conference between these gentlemen, held in Springfield, Ill., it was decided that the Department of Agriculture would pay for the diseased and exposed animals that were slaughtered; a veterinarian, not previously stationed there, and having reputation and experience, would be placed in charge of the Department work; the force of the Department would be increased as required for the extermination of the plague; the separate offices previously maintained by the Department and the State commission would be consolidated; the State commission would do everything in its power to secure the rigid enforcement of the State law.

It was evident from the amount of the appropriation for the current year, and the authority accompanying it, that Congress intended not only that measures should be adopted to prevent the spread of

pleuro-pneumonia from State to State, but also for the extirpation of the disease wherever it might exist. The rules and regulations previously prepared under section 3 of the act approved May 29, 1884, and already accepted by several States, were not entirely adapted to the most efficient exercise of this enlarged power. Accordingly new rules and regulations, as follows, were at once prepared and certified to the governors of all the States and Territories of the Union:

Rules and regulations of the United States Department of Agriculture for the suppression and extirpation of contagious, infectious, and communicable diseases among the domestic animals of the United States.

[Prepared by the Commissioner of Agriculture.]

In pursuance of an act of Congress entitled "An act for the establishment of a Bureau of Animal Industry to prevent the exportation of diseased cattle, and to provide means for the suppression and extirpation of pleuro-pneumonia and other contagious diseases among domestic animals," approved the 29th day of May, 1884, and of section 3 of said act, the following rules and regulations are hereby prepared and adopted for the speedy and effectual suppression and extirpation of contagious, infectious, and communicable diseases among the domestic animals of the United States:

RULES AND REGULATIONS.

(1) Whenever it shall come to the knowledge of the Chief of the Bureau of Animal Industry of the Department of Agriculture that there exists, or there is good cause to believe there exists, any contagious, infectious, or communicable disease among domestic animals in any part of the United States, and he believes there is danger of such disease spreading to other States or Territories, he shall at once direct an inspector to make an investigation as to the existence of said disease.

(2) Said inspector shall at once proceed to the locality where said disease is believed to exist and make an examination of the animals said to be affected with disease, and report the result of such examination to the Chief of the Bureau of Animal Industry.

(3) Should the inspector on such investigation find that a contagious, infectious, or communicable disease exists among the animals examined, and especially pleuro-pneumonia, he shall direct the temporary quarantine of said animals, and the herds among which they are, and adopt such sanitary measures as may be necessary to prevent the spread of the disease, and report his action to the Chief of the Bureau.

He will further notify in writing the owner or owners, or person or persons in charge of such animal or animals, of the existence of the contagious disease, and that said animal or animals have been placed in quarantine, and warn him or them from moving said animal or animals under penalty of sections 6 and 7 of the act of Congress approved May 29, 1884.

(4) When the Chief of the Bureau of Animal Industry is satisfied of the existence of any contagious disease among domestic animals in any locality of the United States, and especially of pleuro-pneumonia, and that there is danger of said disease spreading to other States or Territories, he will report the same to the Commissioner of Agriculture, who will quarantine said locality in the mode and manner as provided in Rule 12. He shall cause a thorough examination of all animals of the kind diseased in said locality, and all such animals found diseased he will cause to be slaughtered. He shall establish a quarantine for a period of not less than ninety days of all animals that have come in contact with diseased animals, or have been on premises or in buildings on or in which diseased animals have been, or have been in any way exposed to disease; and shall make and enforce all such sanitary regulations as the exigencies of the case may require. He will cause to be disinfected in such manner as he deems best all sheds, corrals, yards, barns, and buildings in which diseased animals have been, and until such premises and buildings have been so disinfected and declared free from contagion by certificate in writing signed by an inspector of the Bureau of Animal Industry, no animal or animals shall be permitted to go upon or into said premises and buildings. Should, however, any animal or animals be put upon said premises or into said buildings in violation of this rule and regulation, then such animal or animals shall be placed in quarantine for a period of not less than ninety days, and said premises or buildings be again disinfected. Said second disinfection and the quarantine of said animals to be at the expense of the owner of said premises or buildings.

(5) All animals quarantined by order of the Chief of the Bureau of Animal Industry shall have a chain fastened with a numbered lock placed around their horns, or in case of hornless animals placed around their necks; and a record will be kept showing the number of lock placed upon each animal, name and character of animal, and marks of identification, name of owner, locality, and date of quarantine. The Chief of the Bureau, however, may, in his discretion, in place of chaining said animals, cause the animals to be branded in such manner as he may designate, or may place a guard over the same.

(6) All animals quarantined will be deemed and considered as "affected with contagious disease," and any person or persons moving said quarantined animals from the infected district will be prosecuted under sections 6 and 7 of the act of Congress establishing the Bureau of Animal Industry approved May 29, 1884.

(7) Whenever in the judgment of the Chief of the Bureau of Animal Industry it becomes necessary to kill animals that have been exposed to the contagious disease known as pleuro-pneumonia in order to prevent the spread of said disease from one State or Territory to another, he shall cause the same to be slaughtered.

(8) All animals diseased with pleuro-pneumonia, and all animals exposed to pleuro-pneumonia, that have been condemned to be slaughtered, shall be first appraised as to their value at the time of their condemnation. Said appraisement shall be made in the mode and manner provided for by the law of the State in which they are located, and such compensation on their appraised value will be paid as is provided for by the law of such State. In case such State has no law for the appraisement of the value of animals diseased with pleuro-pneumonia, or that have been exposed to pleuro-pneumonia, or either, then the Chief of the Bureau of Animal Industry shall direct an inspector of the Bureau to convene a board of appraisers to consist of three members, one of whom said inspector shall appoint, one to be appointed by the owner of the animal or animals condemned, and these two will appoint the third; in case the said owner shall neglect or refuse to name an appraiser, then by two appraisers to be appointed by said inspector. This board will appraise the value of the animals condemned and certify to the same in writing under oath, and the amount so fixed by said board shall be paid to the owner of the animals condemned. Should the owner of the animals condemned be dissatisfied with the appraisement, he may appeal from said appraisement to the circuit court of the United States, and the amount found by said court to be the value of the condemned animals will be paid to the owner.

(9) Whenever it is deemed necessary by the Chief of the Bureau of Animal Industry to supervise and inspect any of the lines of transportation operating in the United States, that do business in and through more than one State, or connect with lines doing business in and through other States, and the boats, cars, and stock-yards in connection with the same, he shall designate suitable inspectors for that purpose, and make all necessary regulations for the quarantine and disinfection of all stock-yards, cars, boats, and other vehicles of transportation in which have been, or in which have been transported animals affected with a contagious disease or suspected to have been affected with such a disease. Such cars and other vehicles of transportation declared in quarantine shall not be again used to transport, store, or shelter animals or merchandise until certified to be free of contagion by a certificate signed by the inspector supervising their disinfection, and such stock-yards shall not again have animals placed in them until likewise declared free of contagion.

(10) All quarantined stock, premises, and buildings will be under the charge and supervision of an inspector of the Bureau of Animal Industry, and shall be in no case free from quarantine until so ordered by the Chief of the Bureau.

(11) Whenever any inspector of the Bureau of Animal Industry is prevented or obstructed, or interfered with in the discharge of his duty in the examining of animals suspected to have a contagious disease, or in placing under quarantine animals or premises, or in disinfecting them, he will report the same to the Chief of the Bureau. He will also call upon the sheriff or other police authorities of the locality where said obstruction or interference occurs for aid and protection in the performance of his duty. Should such sheriff or police authorities neglect or refuse to render such aid and protection he will then apply to the United States marshal of said district for the necessary force and assistance needed to protect him in the carrying out of the duties imposed upon him by these rules and regulations and the provisions of the law by authority of which they are made. He will also file with the United States district attorney information of all the facts connected with such obstruction and interference and the names of the party or parties causing the same.

(12) Should from any cause the Chief of the Bureau of Animal Industry find that it is impossible to enforce these rules and regulations in any State, and that in consequence thereof there is great danger that pleuro-pneumonia will spread from said State to other States and Territories, he will report the same to the Commissioner of

Agriculture. Thereupon the Commissioner of Agriculture, if he believes the exigency of the case requires it, will declare said State, in which pleuro-pneumonia exists and in which it is impossible to carry out these rules and regulations, to be quarantined against the exportation of animals of the kind diseased to any other State, Territory, or foreign country. Said order of the Commissioner declaring the quarantine of a State will be published in at least two papers in said State once a week during the existence of said quarantine, and in such other papers as he may select. Notification of the order declaring said quarantine will be certified to the governor of the State quarantined, as well as to the governors of all other States and Territories, and to the agents of all transportation companies doing business in or through said State. All animals of the kind quarantined against in said State will be deemed as animals "affected with contagious disease," and any person moving or transporting any of said animals to any other State or Territory, or delivering any of such animals to any transportation company to be so transported, will be prosecuted under sections 6 and 7 of the act of Congress approved May 29, 1884. Provided, however, that any animal of the kind quarantined against that has been examined by an inspector of the Bureau of Animal Industry and by a certificate in writing signed by such inspector declared to be free from pleuro-pneumonia, may be exported to any other State or Territory, and provided further that said animal shall be exported within forty-eight hours after such examination and signing of said certificate, so that said animal may not be exposed to disease before leaving said State.

(13) Before giving the certificate provided for by Rule 12 the inspector must be furnished with an affidavit made by two reputable and disinterested persons, stating that they have known the animals to be examined for a period of six months immediately prior to the date of examination, and that during that time the animals have not been exposed to pleuro-pneumonia, that they have not been in any of the buildings or on any of the premises, or among any of the herds known to be affected with pleuro-pneumonia, or suspected to be so affected. The inspector may also require further proof as to whether said animals to be examined have been exposed to pleuro-pneumonia.

(14) All rules and regulations heretofore made are hereby revoked, and these rules and regulations will be in full force and effect on and after the 15th day of April, 1887.

NORMAN J. COLMAN,
Commissioner of Agriculture.

These rules were accompanied by a certificate and request for co-operation, of which the following is a copy:

WASHINGTON, D. C., *April* 15, 1887.

I, Norman J. Colman, Commissioner of Agriculture, do hereby certify to the executive authority of the State of —— the foregoing rules and regulations prepared by me for the speedy and effectual suppression and extirpation of contagious diseases among domestic animals of the United States, by virtue of section 3 of an act of Congress approved May 29, 1884, entitled "An act for the establishment of a Bureau of Animal Industry, to prevent the exportation of diseased cattle, and to provide means for the suppression and extirpation of pleuro-pneumonia and other contagious diseases among domestic animals," and I do hereby invite the executive authority of the State of —— to co-operate in the enforcement and execution of said act and of these rules and regulations, made by authority of and in pursuance of the provisions of said act.

—— ——,
Commissioner of Agriculture.

To his excellency,

—— ——,
Governor of the State of ——.

The following form of acceptance was inclosed for the signature of the governors accepting the rules and regulations:

—— —— —— 188—.

I, —— ——, governor of the State of ——, and chief executive officer thereof, do hereby acknowledge the receipt of the rules and regulations certified to by the Commissioner of Agriculture of the United States, as having been prepared by him April 15, 1887, in pursuance of the authority of section 3 of an act of Congress approved May 29, 1884, establishing the Bureau of Animal Industry, and further acknowledge the receipt of the invitation to the executive authority of the State of —— to co-operate in the enforcement of the provisions of said act, and of said rules and regulations.

And on behalf of the State of ———, and by virtue of my authority as the chief executive officer thereof, I do hereby accept the rules and regulations prepared by the Commissioner of Agriculture, April 15, 1887, for the suppression and extirpation of contagious diseases of animals, and agree that the executive authority of the State of ——— will co-operate with the Bureau of Animal Industry in carrying out the provisions of the act of May 29, 1884, to the full extent of its authority; and that I will direct the sheriffs and other peace officers of the State to render all necessary aid and assistance to the inspectors of the Bureau of Animal Industry in the performance of the duties imposed upon them by the said rules and regulations.

——— ———,
Governor of the State of ———.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture, Washington, D. C.

The governors of thirty-four States and Territories have accepted these rules and regulations and agreed to co-operate with the Department in the extirpation of pleuro-pneumonia.

At this time, however, very few States had statutes authorizing the governors to accept such rules and regulations, and some of the governors were doubtful of their power to accept without a special authorization from the legislature. There were also many States which had no laws for the suppression of pleuro-pneumonia, or, having such laws, these were too defective for the enforcement of the proper measures to secure the prompt extirpation of the plague.

To overcome this deficiency in State legislation a form of law suited to meet this emergency was suggested to the legislatures then in session. This act was passed by the legislatures of New Hampshire, Massachusetts, Rhode Island, New York, and Virginia, in the following form:

AN ACT to co-operate with the United States in the suppression and extirpation of pleuro-pneumonia.

The people of the State of New York, represented in senate and assembly, do enact as follows: SECTION 1. The governor is hereby authorized to accept, on behalf of the State, the rules and regulations prepared by the Commissioner of Agriculture, under and in pursuance of section three of an act of Congress approved May twenty-nine, eighteen hundred and eighty-four, entitled "An act for the establishment of a Bureau of Animal Industry, to prevent the exportation of diseased cattle, and to provide means for the suppression and extirpation of pleuro-pneumonia and other contagious diseases among domestic animals," and to co-operate with the authorities of the United States in the enforcement of the provisions of said act.

SEC. 2. The inspectors of the Bureau of Animal Industry of the United States shall have the right of inspection, quarantine, and condemnation of animals affected with any contagious, infectious, or communicable disease, or suspected to be so affected, or that have been exposed to any such disease, and for these purposes are hereby authorized and empowered to enter upon any ground or premises. Said inspectors shall have the power to call on sheriffs, constables, and peace officers to assist them in the discharge of their duties in carrying out the provisions of the act of Congress approved May twenty-nine, eighteen hundred and eighty-four, establishing the Bureau of Animal Industry; and it is hereby made the duty of sheriffs, constables, and peace officers to assist said inspectors when so requested; and said inspectors shall have the same powers and protection as peace officers while engaged in the discharge of their duties.

SEC. 3. All expenses of quarantine, condemnation of animals exposed to disease, and the expenses of any and all measures that may be used to suppress and extirpate pleuro-pneumonia shall be paid by the United States, and in no case shall this State be liable for any damages or expenses of any kind under the provisions of this act.

SEC. 4. This act shall take effect immediately.

This act was also passed by the legislature of Illinois with the following penalty clause:

SEC. 4. Any person violating any order of quarantine made under this act, or any regulation prescribed by the Commissioner of Agriculture for the suppression of pleuro-pneumonia, shall be guilty of a misdemeanor, and upon conviction shall be punished by a fine of not less than $100 nor more than $1,000, or by imprisonment for not more than six months, or both such fine and imprisonment.

In Maryland this work had been going on very harmoniously and successfully for about eight months under the rules and regulations of August 2, 1886, and the State authorities objected to any material change in the status of co-operation, on the ground that they knew the old rules to be successful in that State, while the new ones might be regarded as more or less of an experiment. Some amendments, which appeared desirable to both parties, were consequently made to the old rules, and these, in the amended form, were then accepted by the governor and live-stock sanitary board on behalf of the State of Maryland, and by the Commissioner of Agriculture on th part of the United States. The following is the text of the amended rules and regulations:

Rules and regulations for co-operation between the United States Department of Agriculture and the authorities of the State of Maryland for the suppression and extirpation of contagious pleuro-pneumonia of cattle.

INSPECTION.

(1) The necessary inspectors will be furnished by the Bureau of Animal Industry of the Department of Agriculture.

(2) The properly-constituted inspectors of the Bureau of Animal Industry who are assigned to this State are to be authorized by proper State authorities to make inspections of cattle under the laws of the State. They are to receive such protection and assistance as would be given to State officers engaged in similar work, and shall be permitted to examine quarantined herds whenever so directed by the Commissioner of Agriculture or Chief of the Bureau of Animal Industry.

(3) All reports of inspections will be made to the Bureau of Animal Industry, and a copy of these will then be made and forwarded to the proper State authorities; when, however, any inspector discovers a herd infected with contagious pleuro-pneumonia, he will at once report the same to the proper State authority, as well as to the Bureau of Animal Industry.

(4) The inspectors, while always subject to orders from the Department of Agriculture, will cordially co-operate with State authorities. and will follow instructions received from them, provided they do not conflict with the rules and regulations of the Commissioner of Agriculture and instructions of the Chief of the Bureau of Animal Industry.

QUARANTINE.

(5) When contagious pleuro-pneumonia is discovered in any herd, the owner or person in charge is to be at once notified by the inspector, and the quarantine regulations of the State are to be enforced from that time. The affected animals will be isolated, when possible, from the remainder of the herd, until they can be properly appraised and slaughtered.

(6) To insure a perfect and satisfactory quarantine, a chain fastened with a numbered lock will be placed around the horns, or, with hornless animals, around the neck, and record will be kept showing the number of the lock placed upon each animal in the herd.

(7) The locks and chains will be furnished by the Department of Agriculture, but they will become the property of the State in which they are used. in order that any one tampering with them can be proceeded against legally for injuring or embezzling the property of the State.

(8) Quarantine restrictions once imposed are not to be removed by the State authorities without the consent of the proper officers of the Department of Agriculture.

(9) The period of quarantining will continue at least ninety days after the removal of the last diseased animal from the herd, and will not be removed until the premises have been disinfected. During the whole period of quarantine no animal will be allowed to enter the herd or to leave it, and all animals in the herd will be carefully isolated from other cattle. Any person or persons violating quarantine regulations will be prosecuted under the laws of Maryland by the State authorities.

SLAUGHTER AND COMPENSATION.

(10) All animals affected with or exposed to contagious pleuro-pneumonia are to be slaughtered as soon after their discovery as the necessary arrangements can be

made, and the State veterinarian shall, upon the request of the inspector of the Bureau of Animal Industry in charge of the work, make the necessary order for the slaughter of exposed and diseased animals.

(11) When diseased or exposed animals are reported to the State authorities, they shall promptly take such steps as they desire to confirm the diagnosis. The animals are to be appraised according to the provisions of the State law, and the proper officers of the Bureau of Animal Industry (who will be designated by the Commissioner of Agriculture) notified of the appraisement. If this representative of the Bureau of Animal Industry confirms the diagnosis and approves the appraisement, the Department of Agriculture will purchase the animals of the owner and pay for the same.

(12) All slaughter shall be made on the premises where practicable, and the carcasses, blood, and offal of all diseased animals properly buried thereon. In no case shall driving of diseased or exposed animals over the public highway be permitted unless under supervision of an officer of the Bureau. Nor shall such animals be slaughtered at any slaughter-house where adequate provision is not made for the destruction of carcasses, offal, blood, and all infecting matters.

DISINFECTION.

(12) All necessary disinfection will be conducted by the employés of the Bureau of Animal Industry.

INOCULATION.

(14) No inoculation will be permitted.

(15) The salaries and expenses of all the inspectors assigned to Maryland by the Bureau of Animal Industry, the compensation for all animals slaughtered under their direction, and all other necessary and authorized expenses, shall be paid by the Department of Agriculture.

NORMAN J. COLMAN,
Commissioner of Agriculture.

ANNAPOLIS, MD., *July* 7, *A. D.*, 1887.

I, Henry Lloyd, governor of Maryland, do hereby approve of the foregoing amended rules and regulations, prepared under direction of Hon. Norman J. Colman, Commissioner of Agriculture, for the suppression and extirpation of contagious diseases of animals, and I agree to co-operate with the Bureau of Animal Industry in carrying out the same in this State.

HENRY LLOYD.

The governor of New Jersey did not formally accept the new rules and regulations, because he considered that he had no authority to do this in the absence of a statute authorizing him to take such action. This work had been for some years under the direction of the State board of health, and it was placed in the hands of the officers of the Bureau of Animal Industry to be carried on in accordance with the new rules by the consent both of the governor and of this board.

WORK IN ILLINOIS.

On April 20, 1887, Dr. James Law, professor of veterinary medicine and surgery in Cornell University, took charge of the work for the suppression of pleuro-pneumonia in Cook County, Ill., on behalf of the Department of Agriculture, acting in the capacity of chief inspector of the Bureau of Animal Industry for Illinois. From this time the work was pressed vigorously forward. The cost of inspection, of tagging and registering cattle, of maintaining quarantines, of disinfection, of compensation for slaughtered cattle, of clerical work in the office, of office rent, etc., was paid by the Bureau of Animal Industry. The State paid the expenses of the live-stock commission, of the State veterinarian, and of the appraisers.

Cook County was placed in quarantine May 24 by the publication in the newspapers and by sending a notice to the officers of the railroad and transportation companies. These notices were as follows:

UNITED STATES DEPARTMENT OF AGRICULTURE,
COMMISSIONER'S OFFICE,
Washington, D. C., May 24, 1887.

To the managers and agents of all railroad and other transportation companies throughout the United States, and other persons:

Notice is hereby given by publication, in pursuance of section 7 of an act of Congress approved May 29, 1884, entitled "An act for the establishment of a Bureau of Animal Industry, to prevent the exportation of diseased cattle, and to provide means for the suppression and extirpation of pleuro-pneumonia and other contagious diseases among domestic animals," that a contagious, infectious, and communicable disease, known as pleuro-pneumonia, exists among cattle in the county of Cook, State of Illinois; that all cattle in said infected district are hereby quarantined until further notice, and deemed cattle "affected with a contagious disease," and all persons are prohibited from moving or transporting any cattle from said county of Cook, State of Illinois, to any other State or Territory of the United States, under penalty of sections 6 and 7 of the above entitled act: *Provided, however*, That any cattle that have been examined by an inspector of the Bureau of Animal Industry, and by said inspector are certified to in writing as being free of pleuro-pneumonia, may be transported to any other State or Territory from said infected district within forty-eight hours after being so certified to: *And provided further*, That said inspector is furnished with an affidavit made by two disinterested persons, stating that they have known said cattle for a period of six months immediately prior to to the examination, and that during that time said cattle have not been exposed to pleuro-pneumonia. Said inspector may require further evidence that the cattle have not been exposed, and such proof as he requires must be given him.

The attention of all persons is called to sections 6 and 7 of the act of Congress approved May 29, 1884, establishing the Bureau of Animal Industry, which sections make it a misdemeanor punishable by a fine of not less than $100 nor more than $5,000, or by imprisonment for not more than one year, or by both such fine and imprisonment, for any transportation company or person to receive for transportation, or to transport, or to drive, from one State or Territory to another any live stock affected with any contagious, infectious, or communicable disease, and especially pleuro-pneumonia; or for any person or persons to deliver such affected live stock to any transportation company.

A reward of $100 will be paid to any person giving information to the Chief of the Bureau of Animal Industry that results in the conviction of any person for a violation of sections 6 and 7 of the act of Congress of May 29, 1884.

NORMAN J. COLMAN,
Commissioner of Agriculture.

UNITED STATES DEPARTMENT OF AGRICULTURE,
COMMISSIONER'S OFFICE,
Washington, D. C., May 24, 1887.

To the agents of ——— ———:

You will take notice that, in pursuance of section 7 of an act of Congress approved May 29, 1884, establishing the Bureau of Animal Industry, you are hereby notified that a contagious disease, known as pleuro-pneumonia, exists among cattle in the county of Cook, State of Illinois, in and through which infected district your company is doing business. Said district is hereby declared in quarantine until further notice, and you are hereby directed not to receive for transportation, nor to transport, any cattle from said county, in said State, to any other State or Territory, unless such cattle have first been examined and inspected by an inspector of the United States Bureau of Animal Industry, and said inspector gives a certificate in writing that the cattle examined are free from the contagious disease known as pleuro-pneumonia, and have not been exposed to such disease, in which case said cattle so certified to may be transported from said district within forty-eight hours from the time of examination, and not otherwise. Before examining cattle to certify for transportation the inspector must be furnished with an affidavit, made by two disinterested persons, stating that they have known the cattle for a

period of six months just prior to the examination, and that such cattle have not been exposed to pleuro-pneumonia; that they have not been in any of the buildings, or on any of the premises, or among any of the herds that have been specially quarantined in said district. The inspector may require other proof that the cattle have not been exposed to pleuro-pneumonia, which must be furnished before he gives the certificate.

Provided, however, until further notice, that cattle offered for shipment from the Union Stock Yards at the city of Chicago, Cook County, Ill., may be received and transported without examination and without the certificate above prescribed. Nothing, however, in this proviso to exempt parties making such shipment from the penalty for shipping or offering for shipment cattle affected with pleuro-pneumonia, or cattle from said Cook County, Ill.

Your attention is directed to sections 6 and 7 of the act of Congress approved May 29, 1884, establishing the Bureau of Animal Industry, which sections make it a misdemeanor, punishable by a fine of not less than $100 nor more than $5,000, or by imprisonment for not more than one year, or by both such fine and imprisonment, for any railroad company to receive for transportation, or to transport from one State or Territory to another, any live stock affected with any contagious, infectious, or communicable disease, and especially with the disease commonly known as pleuro-pneumonia, or for any person or persons to deliver such affected live stock to any transportation company.

Your attention is also called to the rules and regulations prepared by the Commissioner of Agriculture, by virtue of the authority conferred upon him by section 3 of the aforementioned act, and especially to the sixth, ninth, and twelfth rules, a copy of said rules and regulations being herein inclosed.

NORMAN J. COLMAN,
Commissioner of Agriculture.

It will be seen that there was a special exception in regard to the Union Stock Yards. There was no evidence that these yards had ever been infected. An agreement was made with the managers that no cattle were to be received from Cook County, and a guard was also established to make certain that this agreement was carried out. Under these conditions it appeared perfectly safe to allow the traffic and interstate commerce passing through these yards to go on without molestation.

Under the same date similar notices were made in reference to Westchester, New York, Kings, Queens, Suffolk, and Richmond Counties in the State of New York; and Baltimore, Howard, Carroll, and Prince George's Counties in the State of Maryland.

To return to the work in Illinois: Beginning with April 20, every bovine animal in the infected district was numbered by a metal tag placed in the ear; this number was so recorded that by means of a double index the animal could be easily located either by knowing the number or the owner's name. *Post-mortem* examinations were made of all cattle from this district which were slaughtered or which died from natural causes. In this way nearly every herd affected was soon located. As no animals in this district could be moved without a permit, there was no serious difficulty in carrying out these regulations. In addition to this, every herd in which the disease was found, and every herd which was known to have been exposed to it, were slaughtered in the presence of our inspectors.

Every stable in which a diseased or suspicious animal was found was disinfected in the most complete manner by a special corps of men organized and instructed for this work.

As a result of these thorough measures the extension of the plague was soon checked, and for the past six months, or since July 28, there have been no fresh or acute cases developed. There have, however, been a considerable number of chronic cases found since that time, and the object of the continued supervision has been to discover and

slaughter all of these as the only sure precaution against a new outbreak of the trouble.

It was the intention to remove all quarantine restrictions in Illinois by January 1, 1888, but the frequent discovery of lesions in the lungs of slaughtered cows which, while not pathognomonic of pleuro-pneumonia, might have been produced by it, led to the postponement of this action. On December 29 an undoubted case of chronic pleuro-pneumonia, with encysted lung tissue, was discovered. From an inquiry which I at once made as to how this case could have escaped the general slaughter of exposed cattle that I supposed had been completed, I learned that about 300 cows in the infected district had been allowed to remain, on the belief that they had not been exposed. It was one of these animals, slaughtered by the desire of the owner, in the presence of one of our inspectors, which revealed the existence of disease. The remainder of the herd was at once slaughtered and the stable thoroughly disinfected. The quarantine restrictions will now be enforced until April 1, and in the meantime the remainder of the cattle that were in this district at the time the malady prevailed will be slaughtered, and it is hoped in this way to prevent any further extension of the quarantine.

From January 1 to December 31, 1887, inclusive, 7,411 herds and premises were inspected in Cook County, Ill., containing 24,059 head of cattle. *Post-mortem* examinations were made on 7,267 animals, which were either slaughtered or had died from disease, and among these 350 were found affected with pleuro-pneumonia. The total number of cattle slaughtered in Illinois during this time, for which compensation was made by the Department, was 1,042. Of these, 172 were diseased, and the owners received for them $3,179.53, an average of $18.42 for each animal, and 870 were exposed and the owners were paid for them $14,153.21, an average of $16.27. The average compensation for the exposed animals is less than for the diseased, for the reason that the value of the carcass was paid by the butcher to the owner, and this amount was deducted from the appraisement, and the owner was paid the difference as compensation from this Department.

There were disinfected in Cook County during the year 677 stables. Some of these were very large, and the work required the constant labor of the disinfecting corps of eight men. The method of disinfecting was to first thoroughly clean the buildings, removing all litter, manure, loose earth, and rotten wood, and then to cover with a mixture of chloride of lime and whitewash. This was applied by means of a powerful force-pump, worked by the members of the disinfecting corps.

The total expenses in Illinois on account of this outbreak, from about September 1, 1886, to December 31, 1887, were $73,991.96. Of this sum, $17,332.74 was paid as compensation for slaughtered cattle. Miscellaneous expenses, including disinfecting material and apparatus, tags, and ringers for inserting the same, record books, office rent, etc., amount to $3,952.52. Traveling expenses of inspectors and other employés, a part of which was for investigating reported outbreaks of disease in the country for a considerable distance around Chicago, amounted to $3,598.99. The remainder was paid for the services of the inspectors, deputy sheriffs, disinfecting corps, and for clerical assistance in the office, amounting to $49,107.71. The amount paid for cattle was to all other expenses as 1 to 3.3.

The large proportional expenses for salaries is due to the fact that from October 1, 1886, to April 20, 1887, no cattle were paid for by the Department, but a large force was kept in the field investigating as to the prevalence of pleuro-pneumonia about Chicago, the size of the district that was infected, in guarding infected stables, and in serving quarantine notices for the State authorities. As the State appropriation was acknowledged on all sides to be too small to cope with the emergency, the Department of Agriculture assumed all of the expense which it could in order that the State funds might be used for the slaughter of cattle.

Between 2,000 and 3,000 head of cattle in the distillery stables and on the Harvey farm were quarantined by the State authorities at a nominal cost, and the animals were slaughtered by the State before the Bureau of Animal Industry was given authority to expend money for this purpose. Neither this quarantine, therefore, nor the compensation for the animals appear in this report, and yet the quarantine was maintained for sixty days by guards paid by the Bureau at an expense of about $100 a day. Of course, cattle when in large herds can be quarantined and slaughtered at relatively small expense for salaries, but when in small lots and scattered over a large territory, or when a constant guard must be maintained, this expense is greatly increased.

Again, since the slaughter of exposed cattle was suspended, there has been a period of watching and investigation to make sure that every vestige of the disease had been destroyed. The period during which the active slaughter of cattle was in progress, and the compensation paid by the Department, was but little over six months, while the total period during which it has been necessary to keep a force in the field has been fifteen months. Finally, the expenses for disinfection have been very heavy, and this is the only outbreak in which any systematic and thorough disinfection has been practiced in the United States by the authorities up to the time the disease was eradicated. If these facts are taken into consideration, they will explain the preponderance of salaries and other expenses over the amount paid for slaughtered cattle.

WORK IN MARYLAND.

Baltimore County, Md., has long been acknowledged to be one of the worst infected localities in the United States. The plague has been very prevalent there, affecting nearly every herd in Baltimore and vicinity and extending for a considerable distance into the country. The contagion has existed in the stables and pastures there for so long a time that they are saturated with it, and in many cases it is extremely difficult to secure their thorough disinfection. The work there has, consequently, been as difficult as it is possible for such work to be. Pleuro-pneumonia was also found to exist in the counties of Anne Arundel, Carroll, Howard, and Prince George's, in the same State. The affected herds in all these counties, with the exception of Baltimore, were immediately slaughtered, and the plague was at once eradicated.

In city districts it is much more difficult to discover affected herds. The owners are often ignorant, with no knowledge of the law, or having such knowledge they conceal the disease. It is therefore only by constant watching and thorough supervision of the movement of animals that the diseased herds are discovered. Until November 10,

1887, the State live-stock sanitary board were unwilling to quarantine all herds in Baltimore and require that no cattle should be moved from one premises to another or allowed upon any vacant lot or highway without a permit. Their reasons for not making such an order were, first, that they thought the disease could be eradicated without these stringent regulations; and, secondly, they doubted their ability to enforce it.

An order was issued, however, which took effect November 10, quarantining all bovine animals within 6 miles of the city hall of Baltimore, and prohibiting any movement of cattle within this district without a permit. The order is as follows:

SPECIAL QUARANTINE REGULATIONS.

Whereas the disease known as contagious pleuro-pneumonia now exists as an epizootic among cattle in the city of Baltimore and portions of the county of Baltimore, in the State of Maryland:

Therefore, in order to prevent the further spread of said contagion, I, Robert Ward, chief veterinary inspector of Maryland, and the State live-stock sanitary board, by virtue of the powers conferred on us by the act of the general assembly of Maryland passed at the January session, 1884, chapter 157, as amended by the act of 1886, chapter 80, do hereby place in quarantine all premises and animals within a radius of 6 miles from the city hall, in Baltimore City, and give notice:

(1) That all persons are prohibited from moving, within the territory aforesaid, from one premises to another, or over any public highway, or unfenced lot or piece of ground, or from bringing into or taking from said territory any animal or animals of the bovine species, except upon obtaining a special permit signed by the chief veterinary inspector for Maryland. All persons are hereby prohibited from driving any animal or animals of the bovine species out of or into the territory aforesaid, except upon obtaining a special permit as above provided. No restrictions, however, are placed upon the movement of bovine animals by rail passing through the county of Baltimore, nor upon steers shipped to either of the stock-yards and intended for immediate slaughter.

(2) The grazing or exposure of animals of the bovine species upon any street, road, lane, or alley, or upon any unfenced lot or piece of ground in the territory aforesaid, is strictly prohibited.

These regulations to take effect on and after the 10th day of November, A. D., 1887.

All sheriffs, deputy sheriffs, constables, and policemen are requested to assist in the enforcement of these regulations.

Done this 24th day of October, A. D., 1887.

ROBERT WARD,
Chief Veterinary Inspector of Maryland.

By order of STATE LIVE STOCK SANITARY BOARD:
T. ALEX. SETH, *Secretary.*

NOTICE TO CATTLEMEN AND DEALERS.

The following additions to the special quarantine regulations of October 24, 1887, are hereby promulgated and made part thereof, by virtue of the powers therein referred to:

(1) By agreement with the State weigher, the four yards at the northwest corner of the State scales pens are set apart for the exclusive use of local cattle intended for immediate slaughter. Cattle for sale for immediate slaughter will be admitted by permit to these pens, and can be taken by permit direct to the place of slaughter. These yards must be entered by Garrison Road (Butcher's Lane).

(2) No cattle from any portion of the quarantined area, extending 6 miles from the city hall of Baltimore, will be admitted to any other of the State scales pens, nor to the Calverton nor Clairmount stock-yards.

(3) All cattle, from whatever source, that have once entered the above-named four yards for local butcher cattle must be sent direct to slaughter and nowhere else. Cattle from these pens may be weighed on the western set of scales, to which no other cattle except those intended for immediate slaughter will be admitted.

(4) Cattle from the counties of Howard, Carroll, Prince George's, and that part of Baltimore County outside of the specially quarantined area extending 6 miles from Baltimore city hall, may be transported to State scales, or either of the stock-yards, as if from unquarantined districts, provided they are accompanied by the special permit and affidavits required for cattle when going out of the State.

(5) Persons driving cattle from outside counties to the Baltimore market must procure a permit before coming within the 6-mile quarantine limit, otherwise they must go into the four pens above designated for butcher cattle.

(6) All cattle coming by rail from the quarantined district of this State, outside the 6-mile limit, must be unloaded at the Calverton quarantine yards, unless they are accompanied by the special permit, with affidavits, as required above.

(7) The Clairmount stock-yards, the Calverton feeding pens, and that portion of the State scale-pens, other than those named above, as reserved for local butcher cattle, must be reserved for the exclusive use of cattle coming by rail from the non-quarantined counties of Maryland and from other States.

DR. ROBERT WARD,
Chief Veterinary Inspector of Maryland.

Approved:
STATE LIVE STOCK SANITARY BOARD,
T. ALEX. SETH, *Secretary.*

To butchers and owners of glue factories and rendering works. To all receivers of dead animals.

SIR: To discover each center of lung-plague infection it is necessary that every bovine animal dying within the quarantined district extending 6 miles outward from the city hall should have its lungs examined by a Government inspector.

You are therefore ordered not to receive at your factory or works, or for conveyance thereto, any dead cattle, young or old, unless accompanied by a permit signed by the chief veterinary inspector of Maryland, and to hold such dead cattle without opening them or removing any chain, lock, or tag from the carcass until such inspector is present.

DR. ROBERT WARD,
Chief Veterinary Inspector of Maryland.

Approved:
STATE LIVE STOCK SANITARY BOARD,
T. ALEX. SETH, *Secretary.*

NOTICE TO COW DEALERS IN THE BALTIMORE DISTRICT.

All persons dealing in cows or other cattle within the Baltimore quarantined district, extending 6 miles in all directions from the city hall, must reserve their stables for the reception of cattle from outside of said district. Cattle from healthy districts may be moved to the dealers' stables upon procuring the necessary permit, and may then by permit be moved to the stables of the buyer, but they can not again be moved from stable to stable. Cattle dealers wishing to trade fresh cows for fat or dry ones will be granted permits to take such fat or dry cows direct to slaughter, or to the quarantine pens at the State scales, but not to their own stables.

Peddling cows is strictly prohibited.

DR. ROBERT WARD,
Chief Veterinary Inspector of Maryland.

Approved:
STATE LIVE-STOCK SANITARY BOARD,
T. ALEX. SETH, *Secretary.*

The work of the Bureau in Maryland is progressing very satisfactorily under these regulations. The State veterinarian and the live-stock sanitary board have co-operated very cordially in enforcing them, and have done much to secure their efficiency. No bovine animal can be moved from or to any premises in the city of Baltimore without having been inspected by a veterinarian in the employ of the Bureau; every cow that dies in any herd in that city is known to these inspectors and is examined as to the cause of its death; every

bovine animal in that district is numbered, and its number and the herd to which it belongs is recorded. It is impossible, therefore, for the disease to exist in a herd for any considerable time before its presence there is detected.

About all of the old infected herds have been destroyed, and the cases which are now found are due to recent infection. Such cases are becoming fewer, and it is believed that this decrease will continue and become more apparent with each month in the future.

From January 1 to December 31, 1887, there were inspected in Maryland 5,704 herds, containing 57,858 head of cattle. *Post-mortem* examinations were made on 2,788 animals, of which 1,137 were found to be affected with pleuro-pneumonia. The total number of stables disinfected was 145. The number of animals affected with pleuro-pneumonia slaughtered in Maryland since July 1, 1886, is 1,442, and of exposed animals (all slaughtered since March 3, 1887), 1,564, making a total of 3,006. The owners received from the Department as compensation for the diseased animals $33,759.01, an average of $23.41 per head; for the exposed animals they received $41,397.71, an average of $26.46 per head.

The total expenses in Maryland in the work of suppressing pleuro-pneumonia from July 1, 1886, to December 31, 1887, were $105,883.81. Of this sum $75,156.72 was paid as compensation for slaughtered cattle. The miscellaneous expenses, including disinfection, locks and chains, tags, record books, etc., were $1,170.16. Traveling expenses amounted to $9,430.49. The total amount paid for salaries was only $20,126.44. The amount paid for cattle was to all other expenses as 1 to 0.41.

We have, with the expenses in Illinois and Maryland, two extremes in the proportion of the amount paid for cattle to that paid for all other purposes. The reason for the large relative expense for salaries in Illinois has been given. The reasons for the small relative expenditures for salaries in Maryland are the large number of affected herds in Baltimore County, which made it easy to find great numbers of affected and exposed cattle; the fact that the work of slaughtering has been continued without intermission, there being no period of investigation covered before the slaughtering began or after it was finished; the small size of the force, which for the most of the time has been insufficient to properly control the movement of cattle. The last reason mentioned was due to the authority given by the State not being sufficient to allow the supervision of the movement of cattle until after November 10, 1887, and, consequently, it would have been a waste of money to increase the force. Since the order of November 10 was made the number of men employed in Maryland has been largely increased, and the relative expenditure for salaries and other expenses will soon be greater than for cattle; but the efficiency of the work has been greatly improved, and the extirpation of the disease will cost less money than if the work were done with a smaller force.

A relatively small expenditure for salaries is therefore no indication either of the efficiency or the economy of the work for the suppression of pleuro-pneumonia. We might have gone on for years in Maryland with twice the expenditure for cattle that was made for all other purposes, but while the prevalence of the plague could have been diminished the contagion could not have been eradicated. To accomplish this result, men must be employed to watch the movement of cattle, and to give permits by which they can be traced, to

guard the stock-yards and other cattle markets, and prevent the entrance of diseased animals, to make *post-mortem* examinations on all animals which die or are slaughtered from the infected district, to investigate all reported outbreaks of disease, and to disinfect all premises where the contagion has existed. This system is undoubtedly expensive in the way of salaries, but it is the only way to eradicate the plague, and in the end it is far more economical than any attempt to control the disease with an inadequate force.

NEW JERSEY.

In New Jersey the work has been steadily progressing. The State is believed to be free from pleuro-pneumonia, with the exception of Hudson County and possibly one or two other adjoining counties. The country districts have been cleared of the contagion wherever it has been discovered. The regulations are now being made and the force organized to establish quarantine and complete control of the movement of cattle in Hudson County, and particularly in Jersey City. So far as our information goes, this is the only county in which there remains any considerable amount of disease.

From January 1 to December 31, 1887, there were inspected in New Jersey 1,428 herds of cattle, containing 16,461 animals. *Post-mortem* examinations were made on the carcasses of 248 animals, of which 113 were found affected with pleuro-pneumonia. The total number of animals slaughtered in New Jersey because affected with this disease was 94, and the number slaughtered for exposure was 117, making a total of 211. The owners received from the Department as compensation for the diseased animals $2,275, an average of $24.20 per head; and for the exposed animals $3,216, an average of $27.48 per head.

The total expenses in New Jersey for the suppression of pleuro-pneumonia have been, to December 31, 1887, $12,146.03. Of this sum $5,491 was paid as compensation for slaughtered cattle. The miscellaneous expenses were $199.33; the traveling expenses, $1,813.43, and the salaries, $4,642.27. The amount paid for cattle was to all other expenses as 1 to 1.2.

NEW YORK.

During the year the two interior counties of Washington and Delaware were found to be infected with pleuro-pneumonia, and although the contagion had been introduced into a considerable number of herds it was promptly eradicated. Very much more of the disease has been found in Westchester County than was anticipated, and more work has been done there than elsewhere in the State. Supervision has been maintained, however, in New York and Kings Counties, and a number of diseased herds were slaughtered in each. After the withdrawal of Prof. James Law from Chicago, or about December 1, he was placed in charge of the work of the Bureau of Animal Industry in the whole State. By orders of the governor of New York it has been possible to maintain quarantines and to establish all necessary regulations for the extirpation of the disease. These orders are as follows:

[Order.]

STATE OF NEW YORK, *Executive Chamber:*

In pursuance of the authority vested in me as governor of the State of New York by chapter 134 of the laws of 1878, entitled "An act in relation to infectious and

contagious diseases of animals," I do hereby prescribe the following regulations for the suppression of contagious diseases among domestic animals and the prevention of the spread of the same:

The local boards of health throughout the State shall report to me at once the breaking out of any contagious disease among the domestic animals in their respective districts, and especially of contagious pleuro-pneumonia among cattle. They shall likewise notify at the same time the chief inspector of the Bureau of Animal Industry of the United States at Washington, D. C., of the appearance of contagious pleuro-pneumonia.

When contagious pleuro-pneumonia exists in any portion of the State of New York the Bureau of Animal Industry of the United States will take charge of the work of suppressing the disease and preventing its spread, as provided by chapter 155 of the laws of 1887, entitled "An act to co-operate with the United States in the suppression and extirpation of pleuro-pneumonia."

The inspectors of the said Bureau of Animal Industry shall place in quarantine all animals affected with contagious pleuro-pneumonia or that have been exposed to contagious pleuro-pneumonia, and all premises infected or believed to be infected with the contagion of said disease. All persons are hereby prohibited from moving quarantined animals from the premises where quarantined, and all persons are prohibited from placing on said premises or among said animals quarantined any healthy animals of the kind among which the contagion of said disease exists.

Whenever the chief inspector of Animal Industry finds that contagious pleuro-pneumonia exists among the herds in any county of this State, and believes there is danger of its spreading to other counties, he shall give notice of the existence of said contagion in a county by publication once a week in at least one newspaper published in said county, and warn all persons from moving any animals of the kind diseased to any other county of the State. He shall likewise notify in writing an agent of each transportation company doing business in said county, and warn said company from transporting any animals of the kind diseased from said county to any other county in the State without a permit from an inspector of the Bureau of Animal Industry. All persons are hereby prohibited from driving or transporting by rail or water or vehicle of any kind, or offering for shipment, any animal of the kind diseased from any county in which contagious pleuro-pneumonia is declared to exist by the chief inspector of the Bureau of Animal Industry, in the manner herein provided, to any other county in the State; provided, however, that animals may be transported to other counties when a permit is given therefor by an inspector of the Bureau of Animal Industry.

All railroads doing business in a county infected with contagious pleuro-pneumonia shall cause their stock-yards, pens, and stock-cars to be cleansed and disinfected in such manner as may be directed by an inspector of the Bureau of Animal Industry, and under the supervision of said inspector.

Given at the capitol in the city of Albany, this 10th day of August, in the year of our Lord 1887.

[L. S.] DAVID B. HILL.

By the governor:
WILLIAM G. RICE,
Private Secretary.

[Order.]

STATE OF NEW YORK, *Executive Chamber:*

In pursuance of the authority vested in me as governor of the State of New York by chapter 134 of the laws of 1878, entitled "An act in relation to infectious and contagious diseases of animals," I do hereby prescribe the following supplemental regulations for the suppression of contagious diseases among domestic animals and the prevention of the spread of the same:

Whenever the chief inspector of the Bureau of Animal Industry shall have given notice as required by executive order of August 10, 1887, of the existence of contagious pleuro-pneumonia, or of the existence of the contagion of that disease, in any county of this State, it shall thereafter be lawful for said chief inspector, in his discretion, to cause all neat cattle in such county to be numbered, tagged, and registered, and all persons are hereby prohibited, after notice given as aforesaid, from moving any such cattle, or allowing any such cattle to stray from any place or premises to any other place or premises, and from allowing any such cattle to be upon any high-

way or upon any uninclosed land without a permit duly issued and signed by an inspector of the said Bureau, and from and after notice given as aforesaid all persons keeping cattle in any such county are hereby required to give immediate notice to an inspector of the said Bureau of the sickness or death of any cattle belonging to them or in their possession, and also of all births that may occur in their herds and of all other additions thereto, and from and after notice given as aforesaid all persons are hereby prohibited from offering or receiving within any such county any cattle for transportation or removal in any manner whatever, and from transporting any cattle in any manner, whether from any place in such county to another place within the county or to a place out of the county, without a special permit duly issued and signed by an inspector of the said Bureau.

Given at the capitol in the city of Albany, this 8th day of December, in the year of our Lord 1887.

[L. S.] DAVID B. HILL.

By the governor:
WILLIAM G. RICE,
Private Secretary.

A force has just been organized in the counties of Westchester, New York, Richmond, Kings, and Queens sufficiently large to tag and register all bovine animals in these counties. The cattle have been quarantined and all movement prohibited unless a permit is first obtained from an inspector of this Department. This system is now (January 26) beginning to work smoothly, and within the next week or two the whole district will be under thorough supervision.

From January 1 to December 31, 1887, there were inspected in New York 1,511 herds of cattle, containing 25,122 animals. *Post-mortem* examinations were made upon 1,347 animals, and of these 447 were found to be affected with pleuro-pneumonia. The total number of animals slaughtered in New York because affected with this disease was 266, and the number slaughtered for exposure was 736, making a total of 1,002 head. The owners received from the Department as compensation for the diseased animals $6,317.25, an average of $23.75 per head; and for the exposed animals $15,577.41, an average of $21.16 per head.

The total expenses in New York for the suppression of pleuro-pneumonia have been, to December 31, 1887, $30,632.49. Of this sum $21,894.66 was paid as compensation for slaughtered cattle. The miscellaneous expenses were $156.95; the salaries, $6,036.85; the traveling expenses were $2,544.03. The amount paid for cattle was to all other expenses as 1 to 0.39.

In New York the work has been under substantially the same conditions as in Maryland, with many large herds infected and these easily found, and until recently without any attempt to supervise all movement of cattle within the infected counties. The relation of the different items of expenditure was also very much the same in the two cases.

In New York there has been a market for the carcasses of exposed animals, and therefore the compensation paid for such animals was less than for the diseased ones. In New Jersey the law is such that it is, as a rule, impracticable to utilize the carcasses of exposed cattle, and hence the average compensation for these has been greater than for the diseased ones. Taking these variable conditions into consideration, it will be observed that the various items of expenditure correspond quite closely in the different States.

To increase the facility of comparison the following table is added:

*Table showing the work of the Bureau of Animal Industry for the suppression of pleuro-pneumonia.**

	Illinois.	Maryland.	New Jersey.	New York.	Total and average.
Herds inspected	7,411	5,704	1,428	1,511	16,054
Cattle inspected	24,059	57,858	16,461	25,122	123,500
Post-mortem examinations	7,267	2,788	248	1,347	11,650
Found diseased on *post-mortem*	350	1,137	113	447	2,047
Diseased cattle slaughtered with compensation	172	1,442	94	266	1,974
Exposed cattle slaughtered with compensation	870	1,564	117	736	3,287
Total compensation for diseased cattle	$3,179.53	$33,759.01	$2,275.00	$6,317.25	$45,530.79
Average compensation for diseased cattle	$18.42	$23.41	$24.20	$23.75	$23.06
Total compensation for exposed cattle	$14,153.21	$41,397.71	$3,216.00	$15,577.41	$74,344.33
Average compensation for exposed cattle	$16.27	$26.46	$27.48	$21.16	$22.61
Salary expense	$49,107.71	$20,126.44	$4,642.27	$6,036.85	$79,913.27
Traveling expenses	$3,598.99	$9,430.49	$1,813.43	$2,544.03	$17,386.94
Miscellaneous	$3,952.52	$1,170.16	$199.33	$156.95	$5,478.96
Total	$73,991.96	$105,883.81	$12,146.03	$30,632.49	$222,654.29
Ratio between amount paid for cattle and all other expenses	1:3.3	1:0.41	1:1.2	1:0.39	1:0.85

*The slaughter of affected cattle and expenses in Maryland are from July 1, 1886. The salaries, traveling, and miscellaneous expenses in Illinois are from September 1, 1886. All other items are from January 1, 1887, and all are brought up to December 31, 1887.

DISTRICT OF COLUMBIA.

It was known that pleuro-pneumonia existed to a considerable extent in the District of Columbia within the last three or four years, but the inspections and supervision of the inspectors of the Bureau of Animal Industry, together with the activity of the health department, led to its disappearance. To determine definitely as to whether the contagion was still affecting any herds, the Commissioners of the District, at the request of the Commissioner of Agriculture, issued an order authorizing the inspectors of the Bureau to make an examination of all cattle in the District. The inspectors were at once placed in the field, and have gone over the whole District, examining carefully all the cattle that were found. Their reports show the inspection of 798 herds, containing 3,268 animals, in none of which was pleuro-pneumonia found. As a careful inquiry has also been made in the counties of Maryland which adjoin the District without discovering the plague, it may be safely concluded that this section is now free from it.

VIRGINIA.

A thorough inspection has also been made during the year in those parts of Virginia where pleuro-pneumonia has been reported in past years. The inspections covered the careful examination of 3,753 head of cattle contained in 353 different herds. In none of these was the plague discovered.

Within a few days a large herd has been reported as affected, and a single *post-mortem* examination indicates that the disease is pleuro-pneumonia, though a further investigation will be made before a decision is reached.

PENNSYLVANIA.

The State authorities of Pennsylvania have not accepted the rules and regulations of the Department of Agriculture, nor have they

agreed to co-operate with the Department for the suppression of pleuro-pneumonia. They have, however, expressed a willingness to have the inspectors of the Department make an investigation of alleged outbreaks of the disease, and of its prevalence in any part of the State. Two inspectors were detailed for such investigation in the month of October, 1887, and have been steadily at work there since that time. They have found no herds affected with the plague except such as were known to the State authorities, and there are at this time but very few of these.

There has been much anxiety felt in many parts of the country in regard to the existence of pleuro-pneumonia in Pennsylvania. It would appear from the official information obtained by this Department that the extent of the disease in that State has been greatly overestimated. Unfortunately, the authorities in charge of this work in Pennsylvania have opinions as to the measures necessary to eradicate the disease which are not shared by the authorities of other States, or by the majority of the veterinary profession. They not only practice inoculation, but they spare those animals which are mildly affected, and after the ordinary period of quarantine allow them to mingle again with other cattle and to be sent to the markets of that or other States. Such inoculated and convalescent cattle are almost universally regarded as dangerous and capable of communicating the contagion to others for an indefinite period. So much alarm has been expressed because of the danger of the plague being spread by these cattle that the Department has offered to purchase and slaughter without cost to the State all exposed animals which the local authorities were unwilling to destroy at State expense. A favorable reply was made to this proposition, but no action has been taken on it, and I learn that it is proposed to soon release from quarantine the affected herds at Frankford, in which it is alleged there still exist chronic cases of the malady.

It would appear from these facts that there should be some provision in the national law which would enable this Department to protect other States in such cases more perfectly than is at present possible.*

MASSACHUSETTS.

Early in the year the discovery of cases of acute pleuro-pneumonia was reported from Boston, and the Department was requested by the governor to assist the State board in investigations as to its prevalence and in the enforcement of measures for its eradication. Inspectors were at once sent there, who found that the affected animals had recently been shipped there from Buffalo, N. Y., and it appeared that they had either come to Buffalo from Chicago or had mingled there with cows from Chicago. A thorough inspection and supervision of the dairies about Boston was kept up for several months, and particularly of the herds in which had been introduced those animals which came in the same car with the affected ones. Fortunately but few cases occurred, and it was only found necessary to destroy a very small number of animals.

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* Since the writing of this report the authorities of the State of Pennsylvania have signed an agreement for co-operation with the Bureau of Animal Industry. Inoculation will be no longer practiced, and all diseased and exposed animals will be slaughtered as soon as discovered.

CONNECTICUT.

The authorities of Connecticut have also failed to accept the rules and regulations of the Department, partly, no doubt, because there has been but very little pleuro-pneumonia in the State. There is now one affected herd in quarantine, and one other that is quarantined as suspicious. Correspondence is now in progress in reference to the affected herd and it will probably be purchased and slaughtered by the Department within a short time.

CONCLUDING REMARKS.

The progress of the work for the extirpation of pleuro-pneumonia during the last year has been extremely satisfactory. This disease has been eradicated from Illinois, from two counties in New York, from two counties in New Jersey, and from three counties in Maryland. It is now almost, if not quite, confined to five counties in New York, two counties in New Jersey, and one county in Maryland, in all of which active work is in progress. There are outside of these counties one herd in Connecticut, two herds in Pennsylvania, and one herd in Virginia believed to be diseased and which are in quarantine.

Compared with the situation when the Bureau of Animal Industry was established, the present condition is certainly very reassuring. In 1884 pleuro-pneumonia existed in two counties in Ohio, in five counties in Illinois, one county in Kentucky, and early in 1885 in one county in Missouri. At that time or since it has existed in one county in Massachusetts, eight counties in New York, seven counties in New Jersey, one county in Delaware, five counties in Maryland, two counties in Virginia, and in the District of Columbia. It has also existed in several counties in Pennsylvania, in reference to which the Department has not complete information. The work necessary to eradicate the disease in Westchester County, N. Y., and in Baltimore County, Md., has probably been more than half completed in each case.

In the counties of New York, Kings, and Queens, in the State of New York, and in Hudson County, N. J., there will be a large amount of very expensive work to do. There is every reason to believe, however, that this work can be practically completed and the plague exterminated by the end of the next fiscal year, if it can be carried on under the same authority and with no greater obstacles than have been encountered up to this time.

Owing to the apprehension existing as to the danger of pleuro-pneumonia being disseminated by cars in which diseased cattle had been transported, the following circular in reference to disinfection was prepared and sent to transportation companies, and has been very generally observed:

U. S. DEPARTMENT OF AGRICULTURE,
COMMISSIONER'S OFFICE,
Washington, D. C., May 31, 1887.

To the managers of all railroads and transportation companies in the United States:

Your attention is called to the fact that contagious pleuro-pneumonia exists among cattle in the States of Illinois, Maryland, and New York, and that the infected districts in said States have been duly quarantined by the Department of Agriculture in the manner provided by the act of Congress of May 29, 1884, establishing the Bureau of Animal Industry.

The existence of this contagious disease in such important cattle centers as these States is a danger so menacing to the cattle interests of the United States that it calls for the most prompt, thorough, and energetic measures that can be taken, not only by the National Government, but also by all parties interested in the preservation of the great cattle industry of the country.

No persons or class of persons are more interested in the safety and growth of this industry than transportation companies, who derive a very large proportion of their earnings from the shipment of cattle and their products, and none should be more active and energetic in enforcing such measures as are necessary to stamp out this disease and prevent its possible spread.

The insidious character of this disease, its easy and imperceptible propagation by contact with animals having the germs of disease and giving no outward symptoms of its presence, the contraction of the plague from infected cars, the spreading of the germs by means of manure carried in uncleansed cars from place to place, all make it a matter of grave concern, and render it necessary that stringent measures should be adopted to protect the cattle interests of the country from this great evil.

I have, therefore, to suggest and to request that all transportation companies shall establish on their respective lines a rule, and see that it is rigidly enforced, that all cars that have carried live stock shall be thoroughly cleansed on the discharging of their freight, and not allowed to leave the freight or stock yards before this is done. Also that the said cars shall be carefully disinfected in the following manner:

(1) Remove all litter and manure.

(2) Wash the car with water thoroughly and until clean.

(3) Saturate the walls and floors with a solution made by dissolving 4 ounces of chloride of lime to each gallon of water. Stock-yards and pens should be cleansed and disinfected at least once a week.

Transportation companies having connections with infected districts should require parties offering cattle for shipment to present, at point of loading, affidavits of the owner and two disinterested persons, stating that the cattle to be shipped have been known to affiants for at least six months next preceding, and that the said cattle have not been in any of said districts and have not come in contact with any cattle from said districts. Said affidavits should be attached to and accompany the way-bill to point of destination.

As several very extensive outbreaks of pleuro-pneumonia have recently been traced to cattle that had been shipped from infected districts a considerable distance by rail, the necessity of these precautions can not be overestimated, and if enforced they would be a material safeguard against the spread of this disease.

Railroad companies can be of the greatest assistance to the Bureau of Animal Industry in its work of extirpating pleuro-pneumonia, if they will co-operate with it and assist in maintaining the rules and regulations prescribed by me on April 15, 1887, and the quarantine orders since made.

I hope this support and assistance will be cordially given.

Very respectfully,

NORMAN J. COLMAN,
Commissioner of Agriculture.

INVESTIGATION OF REPORTED DISEASES.

A great number of investigations have been made during the year to determine the nature of diseases supposed to be contagious. Special attention has been given to outbreaks of disease among cattle in which the symptoms at all resembled those of pleuro-pneumonia. While requests for such investigation have been more numerous from the States where lung plague is known to exist, they have by no means been confined to such sections, but have come from all parts of the country. It is hoped by such inquiries that the Department may receive early information of any fresh outbreaks of pleuro-pneumonia which occur, and in case of other maladies may be able to give directions of value for the treatment and prevention. It has been discovered by these investigations that there are a number of diseases affecting the live stock of the country which have been hitherto undescribed, or about which but little is known. Such diseases are taken up and studied from a scientific standpoint whenever an opportunity is offered.

CO-OPERATION TO PREVENT LOSSES FROM SOUTHERN FEVER.

The losses from Southern fever, or so-called Texas fever, became so heavy in the Western States and Territories that most stringent local quarantines were adopted, which, since 1885, have threatened to entirely destroy the trade in cattle that had previously found an outlet in this direction. The prosperity of the Southwest, and particularly of Texas, is so dependent, under existing conditions, upon an outlet for cattle as unrestricted as is consistent with the safety of stock in other States, that particular attention has been given to this subject.

An investigation was first made as to the parts of Texas from which animals were capable of carrying the virus of this disease, and it was demonstrated that there is a large section in that State from which cattle may be taken without danger, as they are incapable of disseminating this malady. There should consequently be no restrictions placed upon cattle from that district.

Two agents of the Bureau of Animal Industry have been employed to co-operate both with the shippers and drivers of cattle in Texas and with the authorities of those States and Territories to which these animals were taken as store cattle, in order to facilitate this traffic and prevent losses from it. No quarantine regulations have been made by the Department in connection with this disease, but the aim has been to furnish full information to both parties and to endeavor to maintain harmonious relations between them. The agents of the Bureau were able to show that certain herds of cattle came from parts of Texas where no infection existed, and these were consequently admitted to their destination without quarantine. Other herds from the infected district were shown to have been outside of that district for more than ninety days, and as this is about the limit of time the infection can be carried, these also could be sold without restriction.

On the other hand, full information was furnished to shippers in Texas of the quarantine restrictions in other parts of the country, and they were advised as to what cattle could be safely shipped and which ones should be held. In this way both the losses from disease and from unexpected quarantine were reduced to a minimum.

This enormous interstate commerce in cattle from Texas is still in a precarious condition, and should have the careful supervision of the National Government to protect it from unjust local restrictions, and to so regulate it that other States will be protected as far as possible from loss by disease.

The losses which have occurred from Southern fever during the past year have been mostly caused by Southern cattle shipped for immediate slaughter—a class of cattle which are allowed by the animal industry law to be shipped for this purpose without other restrictions than that they shall only be unloaded in transit for food and water. Such animals are transported in the same cars and placed in the same pens in stock-yards that are used for Northern cattle, and the result is that many of the latter are infected and die. This loss occurs among cattle which are sold at the stock-yards for feeding purposes, and has become so serious that farmers can no longer purchase with safety such feeders at the large stock-yards during the summer and early fall months.

The transportation and stock-yards companies should set apart certain cars and certain lanes and pens to be used exclusively by

cattle from the infected districts of the country, and in this way the losses from this disease, which are now very heavy, might be almost entirely prevented.

SCIENTIFIC INVESTIGATION OF DISEASES.

For a number of years a scientific investigation has been conducted by this Bureau of the Department into the nature of the more important contagious diseases of animals. Since this investigation was begun the ideas of the medical profession in regard to such diseases have been revolutionized and a new science has been built up. The work done here has been equal in scientific accuracy to that done in any part of the world, and has added much to this department of knowledge.

More attention has been devoted to the study of hog cholera than other diseases because of the heavy annual losses which it causes. These investigations show that there are two distinct diseases which are popularly spoken of as hog cholera. The germs of these diseases have been isolated and studied, and we know the conditions under which they can exist and multiply outside of the animal, and how they can be destroyed in such situations. This is a long step in advance, and it makes our knowledge of these maladies equal to that which has been acquired with the best studied diseases of people. True, we have discovered no medicine that will act as a specific and cure the plague, but the same may be said in reference to the contagious diseases of mankind. The value of such work must be found principally in the methods of prevention which it suggests and makes possible, and which are really of much more value than any method of treatment could be.

With hog cholera we find that lime is a most efficient disinfectant, and that by its use in very limited quantities the contagion may be destroyed in water, in organic accumulations, and in the soil. Other methods of prevention, including inoculation and various proposed forms of treatment, have been tested without satisfactory results. There are several promising lines of investigation still unstudied, which will be taken up as rapidly as possible.

The scientific investigations of the contagious diseases of animals should be extended and made to cover a wider field than is now possible, both for the importance of preventing these diseases and the light which such investigations throw upon the plagues which affect mankind. There are many diseases which should receive a most careful study. Among these the most common are anthrax, glanders, and tuberculosis, the germs of which also affect people, and which, on that account, we have hesitated to study very extensively in the Department building where so many persons are employed, and where there are no facilities for safely disposing of the contagious material. The present laboratory is in the garret and can not be made suitable for this kind of work. For this reason the investigations have progressed slowly, and many which should have been prosecuted have not been undertaken. There is no more promising field of scientific investigation than this, and none in which there is an opportunity to achieve results of more value to our people.

INVESTIGATION AS TO THE CONDITION OF THE ANIMAL INDUSTRY.

Under this part of its duty the Bureau has each year taken up one or more lines of investigation that have not been elucidated by the

general census returns or by the reports of the Statistician of the Department. During the past year a very thorough inquiry has been made as to the number and value of the thorough-bred cattle of different varieties in the United States. A separate study is now being made of the sheep industry, its condition, the methods by which it is conducted in the various sections of the country, and the means by which it can be improved and made more profitable.

The investigations of this character have been made in a comparatively inexpensive manner by the appointment of one or two agents having special knowledge of the subject. The results obtained in the past have been accurate and of very great value.

CLERICAL WORK OF THE BUREAU.

Since the passage of the appropriation act for the current year the clerical work of the Bureau has greatly increased. There has been a large correspondence from all sections of the country in reference to outbreaks of disease, and requesting copies of reports or information on special subjects connected with stock-raising.

It has also required much labor to make a record of the reports of all the different employés and to supervise their work and expenditures. This work has been organized as rapidly as possible and systematized, so that it is done with a minimum number of employés.

The details of the work of this Bureau are published in annual reports, which show the work done and the information obtained during the year. There is, however, an increasing demand for special reports on various subjects, which shall collect and summarize all attainable knowledge bearing on the particular subject treated. It seems to me very desirable that such special reports on matters of interest and importance should be issued from time to time, and more attention will in the future be devoted to this branch of the work.

FURTHER INVESTIGATIONS ON THE NATURE AND PREVENTION OF HOG CHOLERA.

An extensive outbreak of hog cholera near the city of Washington during the months of November and December, 1887, afforded the opportunity of examining more carefully the condition of the lungs in the various types of this disease as contrasted with swine plague or true infectious pneumonia. At the same time the bacteriological examination re-affirmed the constant presence of the bacterium described three years ago in genuine hog cholera and its causal relation to this disease. It is to be hoped that the rather stubborn and wholly unfounded position maintained in some quarters that there is no disease such as hog cholera independent of swine plague will be given up. This is the more important inasmuch as hog cholera is a more prevalent and more virulent disease than swine plague. At least five epizootics have been observed in the District of Columbia to one of swine plague. In order to combat any bacterial disease it is absolutely essential that all facts connected with the life history of the bacteria be taken into account, and this implies the frank acceptance of results of investigations if the evidence has been fully and unreservedly presented.

The history of the outbreak, as far as could be ascertained, was briefly as follows: On October 28, there were in all 119 swine, chiefly

young pigs, weighing from 50 to 100 pounds. Most of these had been purchased in the city markets. At this same time 20 boar pigs were castrated. Within two weeks these began to die, and soon after the others took sick, dying at the rate of 3 to 4 a day. Less than three weeks after the first deaths only 67 remained out of the 119. At the end of the year only about a dozen were alive out of the entire herd. These may have acquired an immunity.

The animals were kept in pens on the top of a low hillock, sheltered from the weather by large boxes. They were swill-fed, and this may account for their feeble resistance to the disease. In most of them the feeding had induced a cirrhosis of the liver, with softening of the parenchyma. The origin of the disease could not be traced, as the animals had come from various quarters. The city markets had proved themselves the source of disease in several purchases of pigs for experimental purposes. It is barely possible that the disease was inoculated during the operation of castration by the instruments used.

The autopsy and bacteriological notes of the individual cases of this outbreak will be reserved for the report of the Bureau for 1887. A brief summary of all the cases, however, will be given, together with some interesting observations and deductions.

The spleen and lungs were the only organs upon which bacteriological observations were made:

In making cultures from the spleen the following method was usually adopted. At the autopsy the abdomen was carefully laid open by first removing the skin and then cutting through the abdominal muscles with flamed instruments. The flaps laid back brought into view the spleen not touched as yet by any instrument. It was then drawn out with flamed forceps, severed from its attachments with flamed scissors, and placed in a large bottle plugged with cotton wool and previously subjected to a temperature of 150°–160° C. for three hours. In this way it was taken to the laboratory, and either immediately examined or kept in the refrigerator below 55° F. over night. In making cultures the spleen was placed on a sterile glass support and the surface thoroughly charred with a red-hot platinum spatula. This was always done, although usually unnecessary, when we consider the momentary exposure to the air in transferring the spleen from the abdomen to the bottle. It may, however, destroy any bacteria which have entered the peritoneal cavity through ulcerations since. In chronic cases, cocci resembling those of suppuration are not infrequent in the peritoneal fluid. Through this charred area an incision or rent was made and a platinum wire or loop introduced with which a tube of gelatine or beef beef-infusion was inoculated. When roll cultures were made a minute bit of spleen pulp was torn away from beneath the charred portion and stirred about in the liquefied gelatine. From this usually a second tube was prepared. Experience of past years had shown that frequently this is not sufficient to insure the fertility of the cultures. In chronic cases, with spleen but moderately enlarged, hog cholera bacteria are found in very small numbers. In such cases, bits of spleen are cut out from the charred area with flamed scissors and transferred to tubes of gelatine or beef infusion with or without peptone. Such cultures rarely fail. It might be supposed that the chances of accidental contamination are very great in this process. But a long experience with spleens of healthy animals, and with organs in the study of other diseases, have demonstrated the entire safety of this procedure. Salmon culture tubes, with bits of organs of healthy animals in the bottom covered by nutrient liquids, have remained sterile for months in the laboratory. At present the Esmarch tube or roll culture is perhaps best in most cases.

In nearly all the cases examined both liquid and gelatine cultures were made. The former permit a diagnosis on the following day, while the latter require at least two days, usually three or four, before a reliable diagnosis can be made. The cultures were always examined unstained in a hanging drop, as the bacteria in this way are not deprived of their power of motility, which is one of the important diagnostic characters. Staining cultures was frequently resorted to, but it adds little information to that gained by a careful examination of the hanging drop. When gelatine cultures were examined, the bacteria were always mixed with some sterile beef infusion to bring out their motility.

In a number of cases rabbits were inoculated directly from lung tissue. A small bit, about one-half centimeter cube, was torn up with flamed forceps in a flamed watch glass containing some sterile beef infusion, and the turbid fluid injected beneath the skin of the thigh. The syringe used was an ordinary hypodermic syringe, carefully disinfected by 5 per cent. carbolic acid above and below the piston for one-half hour, both *after* and *before* use, and each time thoroughly rinsed in boiling water. As hog cholera bacteria are destroyed by a 1 per cent. solution of carbolic acid in less than ten minutes, and by a momentary contact with water near the boiling point, the disinfection was certainly all that could be desired. This method was regarded as less open to criticism than the insertion of bits of tissue under the skin. We still stand in need of a syringe which can be disinfected without much trouble, as the above method is extremely tedious. Both kinds of syringes devised by Koch are unsatisfactory. The joints formed by the glass barrel and the metal cap in the syringe, in which the propelling force is air, were found to leak in five out of six samples.

From the fluid injected into rabbits either plate or roll cultures were made, in order to get an idea of the approximate number and the kind of organisms present. In every case the portion of lung tissue from which the inoculations were made had been transferred to sterilized bottles at the autopsy and protected from accidental contamination as carefully as possible.

The high percentage of mortality in epizootics of hog cholera like the foregoing is the first thing to claim our attention. Out of 139 animals not less than 100 perished in the brief space of two months, or over 70 per cent. As no disinfection was resorted to, and no isolation of the healthy attempted, it is difficult to say what number could have been saved. At any rate the above figures indicate the mortality of this disease when left to itself, and it shows that nearly all young animals, such as weigh between 50 and 100 pounds, are susceptible to this disease.

Most of the animals died rather unexpectedly. Only a comparatively small number were visibly diseased some time before death. Since in many there was more or less ulceration in the large intestine, it indicates that animals may be in a very bad condition and become a source of infection for others without showing it.

The swill feeding has already been mentioned as a probable cause of the cirrhosis of the liver observed in so many of these animals. This organ was tough and imparted a gritty sensation to the hand when cut. The parenchyma was softened and degenerated. It seems reasonable to suppose that this chronic malady may have made the herd far more susceptible to the disease, and more especially to the acute hemorrhagic type.

Hemorrhagic lesions.—At least one-third of the cases examined showed lesions of a hemorrhagic character. The most common was an infiltration of the cortical portion of lymphatic glands with blood; sometimes the entire gland appeared hemorrhagic on section. As regards the relative frequency of this condition, the bronchial, posterior mediastinal (aortic), and inguinal glands stand first; next the retro-peritoneal, meso-colic glands, and those in the lesser curvature of the stomach. The mesenteric glands were rarely affected. Accompanying this condition of the lymphatics is usually a very large spleen, its great size being simply due to an engorgement with blood.

Next in frequency were the hemorrhagic lesions of serous membranes in the form of punctiform extravasations, larger ecchymoses, and very rarely of collections of blood infiltrating the muscular layers beneath the serous membrane. These extravasations are most frequent on the auricles and ventricles of the heart, under the serosa of the large and small intestines, beneath the pulmonary pleura, and

in the subcutaneous tissue. In the severest cases blotches appeared on the diaphragm and costal pleura. In about 10 per cent. the kidneys were hemorrhagic. Usually the glomeruli appear as minute blood-red points. To this may be added hemorrhages in the pyramids and extravasations collecting around the papillæ.

The mucous membrane of the stomach in hemorrhagic cases is, as a rule, deeply reddened in the fundus, or else there is hemorrhage into the membrane, more rarely on the surface. The mucosa of the small intestine is usually intact, but that of the large intestine in the acute form of the disease is in the same condition as the stomach. In older cases, when not covered with ulcers, it is either pigmented or dark red, chronically congested. This outbreak was characterized by hemorrhagic lesions more than any other which we have examined. Our experience has been that the early cases are hemorrhagic and are succeeded by those in which ulceration, cellular infiltration of the lymphatics, and marantic conditions, such as serous effusions, predominate. In some of the animals in this outbreak there were most extensive hemorrhages. In one the mucous membrane of the stomach was separated from the muscular coat by an extensive clot one-half inch thick. In five cases (10 per cent.) the lungs were the seat of extensive hemorrhages, which literally converted the most dependent lobes into a blood clot and filled the pleural sacs with blood-stained serum. In a variable number both peritoneal and thoracic cavities contained much blood-stained serum.

Ulcerative lesions.—Ulcers of the large intestine were present in 36 out of 49 cases, or 70 per cent. They varied from very slight to very severe and extensive lesions, involving in a small number nearly the whole mucous membrane of the cæcum and colon. The rectum was quite invariably free from disease. The age of the ulcers can not be determined, as the process of necrosis and subsequent ulceration seems to vary very much in rapidity. In a few cases it was not limited to the mucous membrane, but extended into the muscular wall, producing considerable local inflammation and thickening of the serous membrane. In rare cases the necrosis and cellular infiltration had made the intestinal wall so friable that it broke when handled. When the ulceration was slight, it was frequently confined to the ileo-cæcal valve and adjacent membrane, where the mucosa is pitted with small mucous glands. The ulceration in this situation was accompanied by an extensive neoplastic thickening of the valve beneath the ulcer, indicating that the ulcer was old. In 5 cases (10 per cent.) the lower ileum was ulcerated; the ulcers seemed to have no relation to Peyer's patches.

Very puzzling to the pathologist is the frequent combination of old ulceration with recent hemorrhagic lesions (about 20 per cent.). Is it due to an increase in the virulence of the bacteria in the recesses of the ulcer, so that when carried into the circulation they are able to live in the capillaries, there to multiply until the colonies cause necrosis of the vascular wall, or is it due simply to the introduction of bacteria into the circulation from the ulcerated region without any increase in virulence? These questions are of great practical importance in the final solution of the problem how severe epidemics may suddenly arise, and seemingly from mild, chronic cases.

Complications.—Peritonitis, pleuritis, and pericarditis were not uncommon complications, usually accompanying old ulceration. These may be caused by septic bacteria gaining entrance through

the ulcerations. In fact, cocci, closely resembling those of suppuration, are usually found in the peritoneal cavity of chronic cases.

Lung lesions.—This epizootic was studied mainly for the purpose of determining the condition of the lungs in hog cholera. We shall see in the following article that swine plague is essentially a disease of the lungs, secondarily of the digestive tract. It may be possible to find some cases of swine plague in which the large intestines are primarily diseased. Thus far they have not come to our notice. From the facts obtained from this epizootic we may safely assume that hog cholera produces no lesions which may not be found in the lungs of apparently healthy animals. In other words, the lesions which we find there have nothing to do with hog cholera. We must except, however, the hemorrhages found in a small percentage of cases. Such are co-existent with hemorrhages in most other organs, and are not specific lung lesions. The lesions found on *post-mortem* examination were either simple collapse or lobular broncho-pneumonia following it.

Simple collapse usually involved the two ventral dependent lobes,* more rarely portions of the small cephalic and the principal lobes. The collapsed lobes, or groups of lobules interspersed among emphysematus lobules, appeared slightly if at all depressed. The color approached that of muscular tissue. In only a few instances could plugs be found occluding the bronchus.

Sections made from lobules in this condition show a number of interesting features. The alveolar walls are crowded together in some places till they almost touch one another.

Besides the fibrine there may or may not be one or several large cells, round, with much protoplasm inclosing a vesicular nucleus. The bronchi are all patent, the epithelium intact. The alveolar walls are not changed, nor is there any round cell infiltration to be seen. In circumscribed areas the capillary net-work is distended with blood corpuscles, while all the larger vessels are similarly filled with these elements.

In the alveolar ducts there is now and then considerable fibrillar fibrine well brought out by Weigert's stain.

In about 15 per cent. of the animals examined one of the smaller ventral lobes was airless throughout, moderately enlarged. Viewed from the surface the diseased lobe is bright red, dotted with minute pale grayish or yellowish points of a diffuse hazy outline, each not more than 1^{mm} in diameter. They are usually arranged in groups of four and represent the ultimate air cells filled with cellular exudate. The larger bronchi are also occluded. The exudate is yellowish white, so firm that it is possible to tear away the lung tissue with needles without necessarily breaking up the inclosed exudate. It may thus be teased out in the form of branching cylinders, becoming smaller and finally dwindling down to the size of a coarse hair. Microscopic sections reveal a broncho-pneumonia. The alveolar walls are beset with distended capillaries. The alveoli are filled up with cellular masses, fibrine appearing very rarely. In most alveoli the cells are large, round, with vesicular nucleus, evidently derived from the alveolar epithelium. In some alveoli and in the smallest air tubes the cell mass is so dense that individual elements can only be seen with dfficulty. But they appear to be identical with the cells just described. The process seems to be accompanied with very

*** See p. 513 for nomenclature of lobes of pig's lung.**

little inflammation. The desquamation and proliferation goes on in the alveoli and smallest air tubes until they are occluded by the casts described.

Of the 49 animals of the same herd 17 were found with collapse and 8 with lobular broncho-pneumonia; more than one-half, therefore, had some defect of the lungs.

It might be questioned whether such lesions as those of broncho-pneumonia are not due to swine plague bacteria since they closely resemble the appearance found in many swine-plague lungs. This question is effectually disposed of by the inoculation of lung tissue into rabbits. From 16 lungs, 16 rabbits were inoculated. Of these, 8 lungs were involved in simple collapse, 8 in broncho-pnenmonia. Of these 16 rabbits 4 survived; the remainder died of hog cholera. Of the 4 survivors 3 had been inoculated from collapsed lung tissue; 1 from a broncho-pneumonia. It is interesting to note that of these rabbits, 1 died in six days, 4 in seven days, 3 in eight days, 2 in ten days, 1 in thirteen, and 1 in fifteen days after inoculation. Plate cultures from the corresponding bit of lung tissue showed a variable number of colonies almost invariably non-liquefying, and in many cases identified as hog cholera bacteria.

These facts prove that in hog cholera the specific bacteria will find their way to any diseased portion of lung tissue and there multiply to a certain extent. In one case plate cultures from a bit of normal lung tissue showed but one or two colonies, while a bit of collapse tissue from the same lung showed a large number. There is no doubt that the slight exudate and feeble circulation in collapse, and the abundant partly cellular and partly mucous or fibrinous exudate into the air spaces in broncho-pneumonia, furnish a favorable nidus for pathogenic bacteria. These may have been carried there by the blood, or they may have been introduced from without. If the latter supposition prove true, and there are no valid objections to it, diseased lungs in hog cholera may not only become the means of disseminating the disease through the mucus and expired air, but they may become the channel, the weak spot, through which the virus enters the organism.

To elucidate this question if possible, the following instructive experiment was made:

Two pigs (460, 461), about ten weeks old, received into the right lung, December 21, 3^{cc} each of a beef infusion peptone culture, two days old, inoculated from a single colony growing in a roll culture. This had been made from a bit of spleen tissue from pig No. 46 of the outbreak described in these pages. There were about fifty colonies in the tube, all alike. To test the culture a rabbit received at the same time one-ninth^{cc} subcutaneously in the thigh. It died in five days. The spleen was much enlarged, blackish, friable, and contained hog cholera bacteria. A roll culture contained numerous colonies after two days.

No. 460 became very weak in its hind limbs in less than a week; respiration short and quick; bowels relaxed. It was was found dead on the ninth day.

Superficial inguinal glands normal. Petechiæ in the slight deposit of fatty tissue beneath peritoneum of abdominal muscles. Spleen about 12 inches long, 1½ wide, and three-fourths inch thick at the hilus, blackish, friable. A few petechiæ on cortex of left kidney, one cyst the size of a large pea in medullary portion. Large number of small hemorrhages in connective tissue around pelvis of right kidney. Two small urinary cysts not showing on surface. Glands in lesser omentum en-

larged, hemorrhagic throughout. In cæcum and colon an almost continuous yellow sheet of superficial necrosis about 1^{mm} thick covering the mucosa. In lower colon it breaks up into isolated patches simulating ulcers. In microscopic sections this layer is found to consist of necrosed epithelium with some round cells. On Peyer's patches, in lower ileum, a yellow, soft deposit rests, which is not adherent and might be mistaken for chyle. Lobes of right lung glued together and to pericardium. Pleura thickened generally, serum very slight in amount, blood-stained. On lobes of left lung which are also glued together, and on right lung there is a very slight deposit about $\frac{1}{2}^{mm}$ thick in the form of a net-work. As a rule the pleuritis and exudate is most marked on the most dependent portions of the lungs. Cavity of pericardium normal. Lung tissue not hepatized anywhere: trachea and bronchi contain a small quantity of reddish fluid. Bronchial glands and those along posterior aorta hemorrhagic throughout. Cultures from pleural cavities, as well as those from spleen, contain only hog cholera bacteria. As shown in roll cultures they were very numerous in the latter organ.

While No. 460 presented such a well-marked case, No. 461, although presenting at first the same symptoms, slowly recovered. The difference may have been due to the fact that with No. 460 a 6-inch needle was used, while with 461 one only 3 inches long. In the latter case the chance for the passage of bacteria into the lung tissue and thence into the intestines was much poorer.

This experiment proves, (1). That hog cholera bacteria when introduced into the lungs do not produce lung disease; (2), that they may pass from the lungs by way of the pharynx into the digestive tract and there produce their characteristic effect.

Bacteriological observations.—The preceding experiments on rabbits and the intra-thoracic inoculation in case of the pig are sufficient of themselves to establish the fact that the bacteria described in the two preceding reports, and again found in this epizootic, are the cause of hog cholera. It may be added, however, that out of the fifty-six cases (here reported) hog cholera bacteria were found in the spleen of all but six cases. Even in these the cultures made were too few to make the negative evidence of any value.

In many cases the hog cholera bacteria were associated with a rather large bacillus which, for convenience sake, may be called butyric bacillus. This organism was only detected when a bit of spleen was dropped into beef infusion with or without peptone. The cultures kept at about 35° C. contained on the second or third day a cloudy mass limited to the bottom of the tube. The cloud was made up of bacilli, rather large, with a spore in one extremity of the rod, strongly refracting the light. The rod was not enlarged at this end in the fresh state. When dried and stained, the shrunken protoplasm gave the spore-bearing end a swollen appearance, reminding one of the tailed bacteria of older writers. In the few tubes in which this bacillus alone was present the liquid itself remained perfectly clear; when hog cholera bacteria were present it became uniformly but faintly clouded. In liquid cultures without the bit of spleen the bacilli did not develop. This was evidently necessary as food material. In gelatine tubes and roll cultures the bacilli did not grow. Any pathogenic activity can not be ascribed to them. They are anaërobic organisms, probably abundant in the alimentary tract, which were absorbed from ulcers or hemorrhages into the circulation before death as spores, and their development kept in check until that took place. It is also probable that they are important factors in the rapid changes which may take place after death.

In some half a dozen cases decomposition was so far advanced that no thorough examination was made. At first it was thought that the animals had been dead several days, but the person in charge of the herd asserted that they had died during the night. Although

the temperature had fallen below 30° F., decomposition was far advanced. It may be that the live animals crowded upon the dead and thus kept the body warm. Yet this supposition is not capable of accounting for the rapid changes. The hemorrhagic lesions may have enabled various bacteria to become distributed throughout the body. The heat disengaged by them during multiplication, aided by the warmth of the litter, may have been sufficient to keep up the process of decomposition. This *post-mortem* growth may also account for the large number of hog cholera bacteria found in many spleens, although the temperature of the air was, as a rule, far below the point where multiplication may take place.

Buzzards may carry the disease from one place to another. When the dead animals were at all exposed to view they were immediately attacked. Whether hog cholera bacteria are entirely destroyed in the digestive tract of these birds can not be said, but there is nothing in the range of our knowledge of bacteria which will exclude the probability that the bacteria are not all destroyed during the digestive act, and that they may be scattered about by these birds. Such observations should strongly urge all persons who have charge of dead animals to bury or burn them immediately, or to have them destroyed in some other effectual manner.

SOME EXPERIMENTS ON THE LENGTH OF TIME DURING WHICH HOG CHOLERA VIRUS REMAINS ALIVE IN THE SOIL.

The virus of hog cholera is quite tenacious of life, in spite of the fact that no spores are formed. In the report for 1886 it was shown that hog cholera bacteria remained alive in ordinary sterilized drinking water for about four months. They resisted drying under certain conditions for nearly two months. During the past year some preliminary experiments were made concerning the vitality of hog cholera bacteria in the soil. This becomes infected during epizootics of this disease by the discharges of the sick perhaps more thoroughly than anything else in the surroundings of the animals. Moreover, it is the most difficult to disinfect, as we have no knowledge of the depths to which the living virus may be carried by water. If it can be shown that the life of such virus in the soil is speedily destroyed, the precautions to be taken would be quite different from those needed if the virus exists for a long period of time.

The experiments undertaken to solve this question are not completed, but the results thus far obtained are sufficiently definite to warrant publication. A more detailed account will be given in the forthcoming report of the Bureau.

A small flower-pot containing soil was sterilized by moist heat and protected from drying and dust by a large bell jar. On its surface about 100^{cc} of a bouillon peptone culture of hog cholera bacteria was poured and the whole maintained moist and at the laboratory temperature. The soil used was a very fine loam from the grounds of the Department of Agriculture.

Roll cultures from the soil after a few days showed immense numbers of bacteria. From this soil rabbits were inoculated from time to time by stirring up a little soil in some sterile beef infusion and injecting the clear supernatant liquid hypodermically. The soil was infected September 17, 1887. The appended table gives the inoculations into rabbits to test the virulence of the soil. The rabbits which

succumbed died of hog cholera, as indicated by the lesions and the bacteriological examination:

Rabbit inoculated.	After infection of soil.	Died.
October 10	23 days	October 17.
October 18	31 days	October 24.
November 4	46 days	November 12.
December 12	2 months, 2 days	December 23.
January 9		Remains well.
January 23		Do.

The above table shows that infected soil kept moist and at a range of temperature from 60° to 95° F. retained its virulence for rabbits from two to three months. Roll cultures made at this time showed that other bacteria and fungi had found their way into the pot of soil, but no hog cholera bacteria could be detected. This and other reasons drawn from observations of this germ lead to the conclusion that the life becomes extinguished with its pathogenic effect on rabbits. This phase of the question is not to be overlooked, for even if a germ should not longer prove pathogenic, it may regain its original virulence under certain unknown circumstances. The infectious quality of this soil when a month old was demonstrated on pigs by feeding two directly with a tablespoonful each. One showed no disease; the other, unable to rise on the eighteenth day, was killed. The mucosa of the lower ileum and of the entire large intestine was completely necrosed. The intestinal walls were so thick that they failed to collapse when slit open, and were very brittle. Bacteriological examination and rabbit inoculation confirmed the diagnosis of hog cholera.

A pot of sterilized soil which had been saturated throughout with hog cholera germs was placed, December 16, 1887, in the grounds of the Department of Agriculture to test its vitality when exposed to natural conditions. January 5 a rabbit was inoculated from the soil on the surface of the pot. It died January 16 of hog cholera. During the period from December 16 to January 5 the germs had been subjected to alternate freezing and thawing several times without being destroyed. On February 1, one and a half months after infection, the virulence of the same soil was tested on a second rabbit. A severe cold had prevailed since the first inoculation and a thaw was now upon us. The rabbit died of hog cholera on the eighteenth day, indicating that the number of bacteria inoculated must have been very small, and that most of them had already perished. On February 23 another rabbit was inoculated from the surface soil of the same pot. This also died of hog cholera on the eleventh day. Subsequent inoculations remained without effect. Both experiments show that the bacteria perished *between the second and third month.* These and additional experiments now in progress will be reported more in detail in the report of the Bureau.

ORDINARY LIME AS A DISINFECTANT IN HOG CHOLERA AND SWINE PLAGUE.

Experiments made by Liberius* in Germany have demonstrated that the bacteria of typhoid fever and cholera in man are quite readily destroyed with ordinary slaked or unslaked (powdered) lime. Ex-

*Zeitschrift für Hygiene, II (1887), p. 15.

periments made during the summer of 1887 and subsequently, in the Bureau laboratory, with lime upon the virus of hog cholera, have been very satisfactory. In fact, the results were sufficiently positive to warrant its use in place of the corrosive sublimate recommended in the preceding report.

Lime has many advantages over the usual disinfectants. It is cheap, is easily obtained and prepared, and may be used with impunity, as it has no poisonous properties. Nor is the soil injured by the addition of a small percentage of lime.

The method which was followed out in testing its germicide properties was mainly that used by Liberius. The more detailed description and the tabulated results of experiments will be published in the forthcoming report of the Bureau for the year 1887. It will be sufficient to give the results obtained and some remarks on their practical application.

Bacteria of hog cholera free from any organic or inorganic matter are destroyed within one hour by .03 per cent. of lime; in other words, by lime water diluted to one-fourth its original strength (12 per cent.).

When the same bacteria are suspended in bouillon as much as .08 per cent. is necessary to destroy them. When a considerable quantity of coagulated albumen, as much as is contained in boiled, unfiltered beef infusion, was present, and in addition a quantity of egg albumen equivalent to two eggs in a liter, the liquid requires between .3 and .4 per cent. of lime before the bacteria are completely destroyed.

These experiments have reference to the disinfection of the discharges of diseased pigs, in which the amount of organic matter can hardly be so great as in the albuminous liquid above mentioned. It will be seen that as this increases in amount a larger per cent. of lime is required. The lime produces a flocculent precipitate which subsides, leaving a perfectly limpid supernatant liquid. The precipitated portion of lime very probably becomes inert.

Experiments were made with soil in the same way. A rich loam, to which large numbers of hog cholera bacteria suspended in simple bouillon were added, was completely freed from living bacteria within one day by adding one-half per cent. of lime by weight to the soil and mixing the two together. The soil had been previously sterilized before the hog cholera bacteria were added. The lime was used in the form of a 5 and 10 per cent. milk of lime.

In the practical application of lime we may say in general that it should be used in place of mercuric chloride (corrosive sublimate) wherever possible. On wood-work it will be efficient as a whitewash. In infected pens the soil should be covered either by powdered lime or slaked lime in a thin layer. The lime-water will percolate into the deeper layers of the soil and destroy any bacteria which have penetrated into them from the surface.

The experiments on the vitality of hog cholera virus in the soil are not sufficiently comprehensive as yet to be made a basis for practical deductions. But, taking all the evidence, it is safe to say that a period of six months is the maximum and three the minimum time that need be allowed for infected pens and grounds to become safe for occupancy when no disinfection is practiced. Lime as a whitewash on woodwork, and scattered over the soil as slaked lime or as powder, used, in short, wherever there is any suspicion of the presence of virus, may reduce the time during which the ground should be kept unoccupied to two weeks. It is our intention to make experiments on the disin-

fectant power of lime on pens and grounds, so that more definite knowledge of its efficiency on a large scale may be obtained.

It must be borne in mind that none of these precautions can take the place of the isolation of the healthy upon fresh disinfected or uninfected ground. No matter what may be the care taken in disinfection; if one sick animal, manufacturing and carrying virus about within itself, so to speak, be allowed among healthy animals, the disease will spread nevertheless.

The experience which has been gathered at the experimental station during the past three years in the study of this disease has shown, (1). That healthy pigs can be kept free from infection, even on a farm where such disease is constantly kept up for purposes of investigations, provided they are kept in clean pens and there is no transmission of virus from the sick to the well through implements of various kinds, through the carelessness of farm hands carrying it on their clothes, hands, shoes, etc.; (2). That the disease may be carried to a previously uninfected locality by pigs bought from unknown sources; (3). That the disease, supposed to be extinct, may lurk in a chronic form in some animal without being recognized, and that this animal may become the source of an acute outbreak among fresh animals, usually in spring and fall when least expected; (4). That the safest method of raising swine is to breed them on the place, either known to be free from disease or thoroughly disinfected, and kept unoccupied for half a year after an outbreak, and not to allow any communication with neighboring herds, nor to make any additions unless the source be positively known to have been free from disease for at least one year past. These rules will apply to swine plague so far as our knowledge of the disease goes, with exceptions mentioned in the article on that disease.

FURTHER INVESTIGATIONS ON THE ETIOLOGY OF INFECTIOUS PNEUMONIA IN SWINE (SWINE PLAGUE).

In the report for 1886 some preliminary investigations were recorded concerning a disease in swine which differs from hog cholera, not only in the character of the lesions which it presents, but also as regards the organs attacked. The bacteria causing this disease are quite different from those of hog cholera and readily distinguishable by a number of tests. At the time of publication the material which had been examined was not sufficient to warrant a detailed description, nor were proofs adequate for complete demonstration. In February, 1887, an epizootic of this disease, which appeared in the District of Columbia, was carefully studied, and a number of additional important observation made in connection with the peculiar lesions which it produces.

The outbreak referred to appeared on a farm adjoining the experimental station of the Bureau in February, 1887. The farm had been free from swine diseases for several years. No clue could be obtained of the manner in which the disease originated. In the later stages of the outbreak the investigation was complicated by the appearance of hog cholera in the same herd. But sufficient evidence had already been procured to show in a striking manner the non-identity of the two diseases. In this outbreak we were for the first time enabled to convince ourselves of the important fact that in the severer forms croupous and diphtheritic lesions of the large intestine

are usually present. These may lead to superficial necrosis of the mucous membrane and the formation of ulcers if the animals live long enough. This fact makes the diagnosis between hog cholera and swine plague far more difficult, unless bacteriological methods are employed. It at the same time accounts for many discrepancies in the results of former investigators in this field, who regarded all infectious swine diseases due to one cause. In the following pages the autopsy and bacteriological notes are given with a few brief comments. Some of the earlier cases were not examined from a bacteriological standpoint, as the disease was at first regarded as hog cholera by the one in charge of the animals. The notes of the hasty examination are given, however, being valuable as far as they go:

Pig No. 406, male, three months old, died February 1. Skin of the ventral aspect of body and inner surface of limbs reddened. Superficial inguinal glands greatly enlarged and diffusely reddened. Spleen very slightly tumefied; on section dark-colored and rather friable; on cortex small, elevated, blood-red points. Interlobular tissue of liver increased in quantity; gives a harsh, gritty sensation to the hand when cut. Medulla of kidneys deeply congested. Lungs normal. Both ventricles of heart contain small quantities of dark, imperfectly coagulated blood. Considerable serum in pericardial cavity. Lymphatic glands of meso-colon and meso-cæcum greatly tumefied and very dark red throughout. Those of mesentery but slightly affected. Quite extensive, firm adhesions between cæcum and adjacent coils of colon. Large intestine filled with a semi-liquid mass containing much sand. Patch of mucous crypts at base of ileo-cæcal valve converted into an ulcer nearly 2 inches across. The intestinal wall forming the base of this ulcer nearly three-fourths inch thick. The superficial necrotic portion, about one-fourth inch thick, is separated from the deeper neoplastic portion of the wall by an irregular hemorrhagic line. This latter portion is streaked with blood. The serous membrane of this patch is covered with radiating vessels of inflammatory origin, and adherent to colon. Three other ulcers in cæcum about three-fourths inch in diameter; in structure like the above. The mucous membrane of cæcum and colon very deeply congested, approaching hemorrhage. Lower portion of ileum contains a few petechiæ. Stomach normal and filled with food.

This was without doubt a case of genuine hog cholera. The deep ulcerations in the cæcum, taken together with healthy lungs, are sufficient evidence. No cultures were made from the spleen of this animal, although this would have been very desirable in the light of future events. The case is given to indicate the origin of the hog cholera, which appeared later in the same herd, together with the lung disease. The following attempt to infect another animal did not give any definite result:

In order to determine more precisely the nature of the disease affecting 406, No. 358, from another lot, was fed with portions of the spleen and large intestine of this animal. Unfortunately the animal was placed in a pen which had been long infected with hog cholera, but in which the animals had lately failed to take the disease. The feeding took place February 1. It grew very feeble a week after; its appetite began to fail; it finally remained lying down all day, and was found dead February 20.

Autopsy notes.—February 21. Superficial inguinal glands enlarged, bluish-red; parenchyma dotted with bright red points. Some straw-colored serum and a few strings of fibrine in abdominal cavity. Liver dark, filled with blood; right lung hypostatic; right heart filled with dark, partially-coagulated blood. Large intestine distended with consistent fecal masses. Mucosa considerably reddened; minute vessels injected. Two old, healing ulcers, three-eighths inch across, in cæcum; stomach normal; spleen cultures remain sterile.

In the same pen with No. 406 were Nos. 403, 404, and 405. No. 403 died February 16.

Autopsy.—Pig three months old. Skin over throat, inner aspect of limbs, and pubic region, reddened; entire ventral aspect of body slightly so. Subcutaneous fatty tissue tinged red. Superficial inguinals enlarged and deeply reddened throughout their substance. Spleen enlarged and very dark, but firm. The small ventral lobes resting laterally upon the heart, which are most dependent in the natural position of the animal, airless and adherent to costal pleura, which is deeply inflamed where adherent. The smaller air tubes of the hepatized masses are filled with a yellowish purulent exudate. Bronchial glands enlarged and congested. All the lymphatic glands of abdomen tumefied and deeply congested. Large intestine empty. Mucosa deeply inflamed from cæcum to anus, being most severe lowest

down. In colon and rectum it is covered with a continuous layer of exudate stained a dirty yellow and probably diphtheritic. Slight superficial necrosis of the membrane. Numerous ascarides in stomach, which is nearly empty.

This was without doubt a case of genuine swine plague. The exudative deposit on the mucosa of the large intestine has never been observed by us in uncomplicated hog cholera. Unfortunately no bacteriological examination was made.

A very interesting case was presented by No. 402, which had been in the pen in which No. 406 died. On February 17 a very liquid diarrhea set in, which weakened the animal very much. It was found dead February 19. Large patches of the skin of throat, abdomen, and pubic region deeply reddened. Superficial inguinals very large, cortex hemorrhagic. Sheath of penis infiltrated with blood. Patches of diffuse blood extravasation in subcutis, in abdominal, and lower intercostal muscles. Lungs œdematous, a few slender fibers attaching right lung to chest wall. Cephalic lobes emphysematous; small region of ventral lobes hepatized, grayish red. Extravasation of blood beneath pleura on dorsal aspect of lungs, near root. Cortex of bronchial and œsophageal glands infiltrated with blood; bronchi filled with whitish foam. Epicardium dotted with punctiform extravasations on auricles, and near base on ventricles. Small clot on right heart, left empty. Liver bloodless. Kidneys pale, hemorrhage into membrane inclosing papillæ. A few petechiæ on cortex. Serosa of small intestines covered with oblong purplish patches, found to correspond with Peyer's patches, which are very dark throughout. In many there is hemorrhage on the surface. Beneath serosa of large intestine numerous petechiæ and hemorrhages. All glands of abdomen with cortex hemorrhagic. Mucosa of colon very dark, and covered with isolated yellowish-white masses from one-eighth to one-fourth inch in diameter. These are fairly consistent, and come away entire, leaving a slightly depressed surface. In the rectum this exudate has coalesced into a continuous sheet. Fundus of stomach covered with a layer of clotted blood; when removed the exposed mucosa is found dotted with closely-set hemorrhagic points, evidently the source of the hemorrhage.

This case is of considerable interest. In the first place the extensive hemorrhages throughout the body have left the organs almost bloodless. The lungs were without doubt beginning to consolidate, and the very important question arose: Are the swine plague bacteria at times the cause of such severe hemorrhagic lesions as are presented there?

Examination on cover glasses of the parenchyma of the various organs proved negative as regards micro-organisms. A large number of cultures were made with the following results: Two tubes of beef infusion inoculated with shreds of pleural exudate remained sterile. Two tubes of beef infusion peptone received each a bit of spleen tissue. In both large bacilli developed, either single or in long chains, some spore-bearing, the spore causing a considerable local increase in the width of the rods, giving them a spindle-shaped or club-shaped outline, according as the spores were situated nearer the center or one extremity of the rods. A few were observed to execute spontaneous movements.

Two tubes of beef infusion, inoculated each with a bit of liver, contained the same bacilli; also a microbe resembling the swine plague bacteria very closely and a streptococcus. A liquid culture of blood from the heart contained the bacillus only. A gelatine tube culture made by dropping into it a few drops of heart's blood developed numerous translucent waxy colonies, made up of several kinds of bacteria. The gelatine after a few days began to liquefy. Two tube cultures in gelatine, containing each a bit of spleen, began to liquefy after a few days with disengagement of bubbles of gas and a pecular unpleasant odor. The same large bacilli present in both tubes.

These results indicate absence of a perceptible growth of bacteria in the internal organs. Owing to the extensive hemorrhages upon the mucous surfaces, the various microbes found in the cultures gained access to the blood. The bacillus found in almost every culture is presumably some form causing butyric fermentation. This is shown by its spore formation, feeble growth in cultures exposed to the air, and the odor of the cultures. The animal probably died early in the night, and the warm weather then prevailing gave the bacilli ample opportunity to multiply. Their general distribution seems to favor the assumption that the bacilli or their spores were distributed by the blood current before it ceased. The lesions were not due to the bacterium of hog cholera, although resembling this disease, if we except the hemorrhagic condition of Peyer's patches in the ileum, which we had not seen in the severest cases of hog cholera.* Had the disease been hog cholera the bacterium would have been revealed in several or all of the cultures made.

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* Excepting in those fed with liquid cultures. See Annual Report Department of Agriculture for 1886, p. 614.

Were these lesions due to swine plague bacteria?

To determine whether the microbes seen in the impure liquid culture from the liver were swine plague bacteria a rabbit was inoculated by means of a hypodermic syringe beneath the skin of the thigh with about one-eighth^{cc} of this culture. It was found dead within forty-eight hours.

Locally there were blood extravasations into the connective tissue and muscles of the thigh and contiguous abdominal wall. There was also a gelatinous infiltration of the fasciæ of the muscles. Lungs œdematous; spleen dark; parenchyma of liver very friable. Stomach distended with food. Mucosa covered with a layer of tenacious mucus. Immense numbers of bacteria in spleen, liver, and blood from the heart all showing the characteristic polar stain of the swine plague bacteria. Very few in kidneys. From the blood and spleen pure cultures in tubes of gelatine were obtained.

These results prove not only the presence in the liver of this pig of swine plague bacteria, but also the absence of any pathogenic properties of the large bacillus found in all cultures from the pig.

An impure gelatine culture from the blood of this pig inoculated into a rabbit gave precisely the same result. The rabbit died in three days of a septicæmia due to the swine plague bacteria, which were found in abundance in the spleen, liver, and blood. Cultures were equally confirmatory. Hence both blood and liver of the pig contained these bacteria. The appended table gives the results of the inoculations:

Pig No. 402, February 19.

b. i. p.* culture, liver.	gel.† cult. blood.
rabbit, February 24, died February 26 (cults. blood, and spleen contain only swine plague bacteria).	rabbit March 2, died March 5 (cults. liver, blood, contain only swine plague bacteria).

A pig (No. 377), after being deprived of food for nearly a day, was fed February 20 with portions of the spleen, large and small intestine, of No, 402. The handling of the animal resulted in slight lameness for a few days. Its appetite became poor. In a month after feeding (March 23) it was in a dying condition, and was consequently killed for examination.

The *post-mortem* examination gave no clue as to the nature of the disease. There were no indications of hog cholera. There were no specific lesions referable to swine plague. Previous as well as subsequent experiments have convinced us that the specific lung lesions of swine plague can not be produced by feeding. The lesions found are briefly as follows:

Superficial inguinal glands very large, infiltrated with a pale serum; cortex of some of the lobules contain extravasated blood, medullary portion whitish, lardaceous. Peritonitis indicated by very slender threads of fibrine stretched across the coils of intestine. Lungs and digestive tract normal. Right ventricle distended with a clot, the center of which is pale. Two liquid cultures from peritoneal fluid remained sterile.

No. 405 was found dead February 18, after several days of great weakness and diarrhea. The severest lesions were confined to the lungs and the large intestines, as the following *post-mortem* notes indicate:

Patches of skin on the inner aspect of limbs, over the abdomen and pubic region, deeply reddened. Lymphatics of meso-colon enlarged, but pale. The mucous membrane of the large intestine presents throughout a dark red, raw aspect, and is covered more or less entirely with a continuous layer of exudate, which readily comes away. Ventricles of heart filled with very dark, partially coagulated blood. The ventral portion of both lungs, involving perhaps one-half their entire volume, hepatized and portions of it firmly adherent to the thoracic wall, the diaphragm, and pericardium.

The disease seemed to involve all below a horizontal line when the lungs were held in the position normally occupied in the body, as if the agencies producing the lesion had settled into the most dependent portions and there began their pathological action first. The portions affected were thus the small ventral lobes resting on the pericardium, these being lowest in the natural position of the animal, and

* Beef infusion containing 1 per cent. peptone.

† Beef infusion containing 1 per cent. peptone and 10 per cent. gelatine.

portions of the cephalic and principal lobes. Those portions resting against the vertebræ were still normal.

The color of the hepatized regions was grayish red to reddish yellow, sprinkled with closely set yellowish white spots from $\frac{1}{2}^{mm}$ to 5^{mm} in diameter and slightly prominent. On section the same appearance presents throughout the diseased lung tissue. The recently affected lobules are either uniformly and deeply reddened or sprinkled with a large number of very minute whitish points. Odor slightly putrefactive.

The yellowish white masses were firm and cut with a smooth surface. Microscopic examination showed them to be made up of broken down cells, among which were immense numbers of various kinds of bacteria. These lesions were evidently produced by the same cause that we had studied in western outbreaks. There was but one way to speedily isolate the specific microbe from the mass of other microbes which were living in the dead cell masses. Three mice were inoculated by placing beneath the skin of the back bits of lung tissue from the recently diseased areas. A rabbit was inoculated in the thigh in the same way by making an incision through the skin, which had been disinfected with 1 per cent. mercuric chloride, introducing a bit of lung tissue and drawing together the incision with a stitch.

The rabbit died within 24 hours. Very slight purulent envelope about bit of tissue. No other reaction locally. Nearest lymphatic hemorrhagic. In it, as well as in blood from the heart, spleen, and liver, immense numbers of the polar stained bacteria. Cultures in gelatine and liquid from blood pure. Two mice died on the third day. Bacteria present in small numbers. The third died on the fourth day. Immense numbers of the same bacteria in blood from heart. Pure cultures from the latter organ were obtained from each mouse.

Pig No. 405 (bit of lung tissue).

rabbit, Feb. 18 died Feb. 19 (swine plague bacteria only in cultures)	3 mice, Feb. 18 died Feb. 21, 22 cultures from blood contain only swine plague bacteria

One of the most pronounced cases of this disease died February 21, and was examined on the following day.

No. 407. Pig of medium size, white; skin of abdomen, chest, neck, and back deeply reddened. Fat abundant, slightly reddened along the linea alba. Superficial inguinals slightly enlarged; spleen dotted with elevated blood-red points. Liver very dark. Stomach and duodenum normal, the latter bile-stained. In ileum Peyer's patches are visible as groups of small, dark dots; no swelling. Mucosa of cæcum and upper colon of a dirty, blackish color, probably pigmented. A few hæmatomata beneath mucosa. Besides the diffuse pigmentation the mucosa is sprinkled with isolated or confluent masses, about one-eighth to one-fourth inch in diameter, of a dirty grayish-yellow color, loosely adherent to the membrane. When pulled away a slightly depressed surface is exposed. Much of this mass can be easily removed by simply moving the scalpel over it. There are several ulcers in the cæcum with decided loss of substance. The patch of mucous glands at the base of the valve is also converted into an ulcerated mass. Lymphatic glands in abdomen slightly swollen and reddened. Kidneys deeply reddened to tips of papillæ.

On opening the thorax the lungs did not collapse, and a rather disagreeable odor was perceived. As in No. 405, the ventral and cephalic lobes of both lungs were consolidated. The hepatized regions were very hard to the touch, bright red, with yellowish points sprinkled in regularly, indicative of broncho-pneumonia. (See Plates I, II, III, Fig. 1.) The right lung was adherent to chest wall along the hepatized portion. A whitish, spongy membrane was interposed, about 3^{mm} to 5^{mm} thick, inclosing a small quantity of turbid liquid. On removing the lung the membrane remained adherent to pulmonary pleura and was removed with difficulty. A portion of the diaphragm was also firmly attached. The left lung adhered firmly to the costal wall in two places where it was consolidated. The costal pleura was deeply reddened, owing to the injection of a close net-work of minute vessels. Trachea and bronchi filled with whitish foam.

On section, the consolidated region is sharply but irregularly marked off from the normal tissue, very consistent and slightly elevated. The color varies from a bright red (recent) to a grayish red. In all the minute grayish points are present from 1^{mm} to 2^{mm} in diameter, about the same distance apart, and of a hazy outline. The smaller bronchi are filled with a purulent fluid. In the surrounding lobules

in which the disease is more advanced the interlobular tissue is distended with a serous infiltration; the large vessels are filled with very consistent dark clots. Heart rather large; pericardium free; right auricle, ventricle, and large veins distended with thrombi; smaller white thrombus in left ventricle.

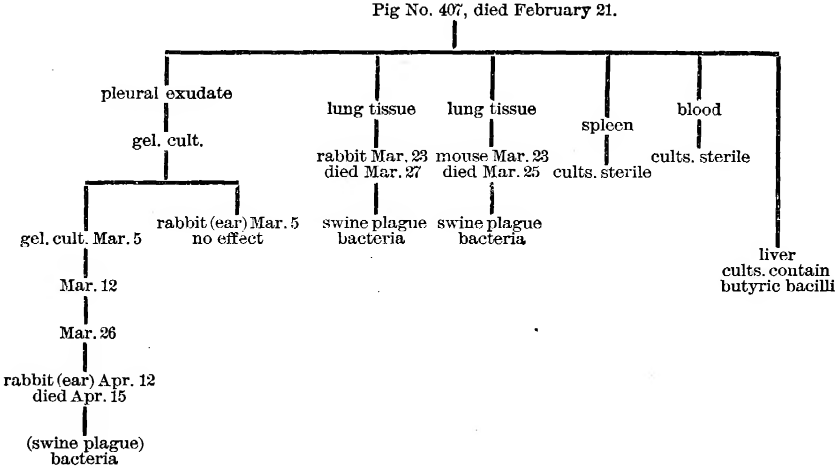
Microscopic examination of the lung tissue in cover-glass preparations shows the presence of numerous bacteria with the polar stain in recent lesions; in older ones they are rare. Other forms are present, but only in small numbers. The pleural exudate was made up of round cells, bound together by bundles of fibrine; it contained few bacteria.

In transverse sections of the large intestine, where a mass of exudite is still attached, the muscular and submucous layers are intact, if we except a slight cellular infiltration near the base of the crypts. The mucous layer, however, is considerably changed. The surface epithelium, including a portion of the crypts of Lieberkühn, is no longer distinguishable, but merges without demarcation into an exudate several millimeters thick, consisting of leucocytes imbedded in a mesh-work of fibrine, the whole refusing to stain. The pathological process seems to be diphtheritic in nature, the membrane being attacked from the digestive tube and not from the submucous tissue.

Pure cultures of swine-plague bacteria in tubes of gelatine were obtained from the pleural exudate. In each needle track a large number of colonies developed. A piece of the false membrane gave the same result. Cover-glass preparations from spleen and liver were negative. Two tubes of beef infusion into which bits of spleen had been dropped remained sterile. Two similar cultures from the liver contain each the bacillus butyricus, evidently of *post-mortem* growth. The blood from the heart was also free from bacteria, for two tubes of gelatine, each inoculated six or seven times with blood, did not develop a single colony.

These results show that the specific microbe is not present in the internal organs, and can only be obtained from the diseased lungs and pleura. A rabbit inoculated in the ear with a bit of lung tissue died within four days. There was no swelling or reddening of the ear. Lungs deeply congested (hypostatic?). Immense numbers of swine plague bacteria in blood, spleen, and liver. Cultures from blood and liver contained only the same organisms. A mouse inoculated with a bit of lung tissue succumbed within two days. Bacteria very scarce in body. Pure cultures of swine plague bacteria were, however, obtained from heart's blood.

Pig No. 407, died February 21.



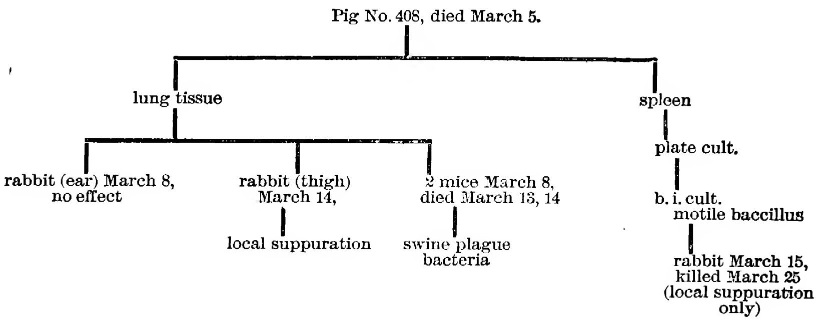
No. 408 from the same farm died March 5. The *post-mortem* examination was delayed forty-eight hours, the temperature being above the freezing point a part of the time.

Skin diffusely reddened over the entire body. On buttocks tough and leathery. The most marked lesions found in the internal organs are briefly as follows: On section of kidneys six or seven petechiæ on each pyramid. In fundus of stomach, which was filled with food, some small erosions of the mucous membrane. In the large intestine, the mucosa of cæcum dark-red, almost blackish, and covered with large ragged ulcerations only 1^{mm} or 2^{mm} deep. The membrane appeared as if gnawed.

The ileo-cæcal valve is almost completely surrounded by ulceration, the base of the ulcers being blackish, and the mucosa much puckered. The colon is bright red, dotted with darker points, and covered with small ulcerations, circular as if punched out. The base of the ulcers is concealed by a creamy mass, the border slightly thickened and intensely reddened. In some places the ulcers number five or six to a square inch. Besides these small ulcers there are several about one-half inch across, resembling the ragged ulceration in the cæcum. The contents of intestine resemble lumps of sand and mud, some extremely hard. Sections through a few of the small circular ulcers show that they have arisen around the mouths of mucous glands.

On opening thorax, lungs collapse. Slight fibrous adhesion of right lung to thoracic wall near diaphragm. In each lung the cephalic, ventral, and a small portion of the principal lobe, as well as the small azygos lobe, solidified. The hepatized portions are bright red, dotted with very minute closely-set, grayish spots, well shown in Fig. 2, Plate III. Examined with a lens these spots have a nebulous appearance. On section this same mottled appearance. A few lobules and groups of lobules are converted into greenish-yellow, consistent, cheesy masses. Trachea and larger bronchi filled with whitish foam. The smaller bronchi clogged with viscid mucus inclosing air bubbles. Cover-glass preparations of alveolar exudate contained cocci, of the spleen no bacteria of any kind. Cultures from the surface of the pleura remained sterile; a liquid culture from the spleen contained three or four forms of bacteria. One of these was evidently the microbe found in former cases. A second form, a motile bacillus, isolated from this culture with the aid of gelatine plates, resembled the bacterium of hog cholera in some features, differing from it in others. Without giving these, suffice it to say that a rabbit inoculated subcutaneously with one-third^{cc} liquid culture was killed in ten days. The lesion was purely local; extensive suppuration of the connection tissue of the inoculated thigh. The lymphatic glands of axilla on the same side enlarged, one of them hemorrhagic throughout. The internal organs were normal; no evidence of those lesions always following inoculation with hog cholera bacteria.

March 8 a rabbit was inoculated by pricking both ears with a lancet and inserting into the wound some of the alveolar exudate from the solidified lung tissue. No result. Another rabbit was inoculated with the same lung tissue a week later, which had been meanwhile kept in the refrigerator. A small bit of lung tissue was placed beneath the skin of the thigh and the wound closed with a stitch. It was killed a week later, though apparently well. A large mass of cheesy pus was found at the place of inoculation in the subcutis. Internal organs normal. Two mice were inoculated March 8 by placing bits of lung tissue beneath the skin at the root of the tail. They died March 13 and 14, respectively. In the heart's blood of both the characteristic bacteria found hitherto, and showing the polar stain very clearly, were found in large numbers. Cultures therefrom corroborated the microscopic examination. A table giving the inoculations is appended:



Another pig (No. 409) had been with Nos. 405 and 406 before January 31. Since February 1 this animal began to fail. It became emaciated and weak, diarrhea set in, a cough was heard when the animal was incited to move. It died March 20. Body very thin; skin of ventral aspect covered with elevated brownish scales one-eighth to one-fourth inch in diameter, easily torn away, and involving only the epidermis. Petechiæ had been observed in the same situation during life ; superficial inguinals considerably tumefied, of a mottled, pale-red color. *Digestive tract.*—Stomach distended with food, cardiac expansion softened and apparently macer-

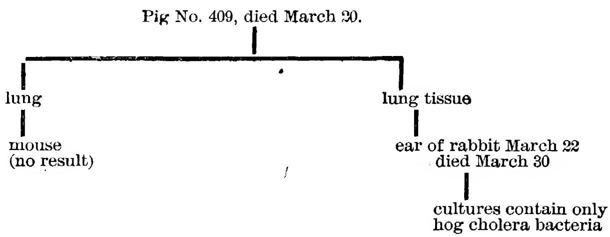
ated. In the large intestine the mucosa was roughened and covered with pigment spots 1^{mm} to 2^{mm} diameter, giving the whole membrane a dark appearance. In the blind end of the cæcum and in several of the saccular dilatations of the colon the mucous membrane is superficially eroded, giving rise to circular, shallow ulcers covered with a whitish deposit. The lungs were extensively hepatized. The solidified portions involved the same regions as those heretofore described—cephalic and ventral lobes and the ventral portions of principal lobes. Only a small area of the principal lobe presents the bright red ground mottled with grayish points. The remainder of the solidified lung tissue is of a uniform greenish, waxy tint, both on surface and section; the bronchi plugged with mucus. In those portions of the principal lobe which appear normal are scattered groups of hepatized lobules. Cover-glass preparations from the diseased regions of older date show chiefly pus corpuscles with irregular fragmentary nucleus staining well in methylene blue. On one cover glass was found a large colony of minute bacteria resembling those of swine plague.

In sections from the hepatized lobes the alveoli were found, as usual, filled with cellular elements. Among these chains of streptococci, consisting of at least 15 to 30 cocci, were found. In some alveoli only a few were present, in others a considerable number of interlacing chains could be seen. This strepococcus, which stains very well, according to Gram, will receive more attention later on. No groups of cocci resembling those of the swine plague bacteria could be found in the few sections examined.

Cultures from spleen and liver were found to contain several kinds of bacteria. A tube culture in gelatine of heart's blood remained permanently free from bacterial growth.

From a cheesy mass in the lungs a large white rabbit was inoculated in both ears. On the following day both were swollen, red, and drooping back. A few days later they were again normal, and although rather quiet and stupid it seemed well. On the eighth day it was found dead.

Slight swelling about lancet puncture on which there is some dried blood. Ear otherwise normal, a few strings of fibrine on intestines, spleen enormously enlarged. Liver dotted with areas of coagulation necrosis 1^{mm} to 2^{mm} across. Extensive pericarditis, the two layers of the pericardium firmly adherent. Pleuritis on both sides. The lesions were those caused by hog cholera bacteria, and these microbes were found in large number in spleen and liver. Only a few in the pericardial exudate, none in blood. Gelatine cultures of spleen and liver and three beef infusion cultures of blood from the heart contained the motile hog cholera bacteria only.



Another animal (No. 410) from the same farm and herd was attacked with a severe skin disease, in which a large area of the skin of the back came away as a slough, exposing the muscular tissue beneath. The animal became reduced and was found dead March 29.

The ventral aspect of the body and limbs covered with round, slightly-raised scabs, about one-fourth inch in diameter, with bluish-red border. The scab, consisting merely of epidermis easily torn away, covers a deep-red surface. The extensive sloughs on the back have already been mentioned. Stomach filled with a turbid liquid, the membrane of fundus reddened and covered with tenacious mucus, which it is almost impossible to scrape away. Mucosa of large intentines of a deep red throughout made up of crowded bright red points. No ulceration. *Lungs* not collapsed; left hypostatic. Both principal lobes œdematous; cephalic half of right lung emphysematous. Hepatization involves, in the right lung, only the extreme tip of cephalic lobe, one-half of ventral lobe, and the ventro-cephalic corner of principal lobe; in the left lung only a few lobules of the ventral lobe. The small median (azygos) lobe is solidified along the border in several places. Right heart

filled with a large thrombus, firmly adherent to papillary muscles. Left heart contains a small dark clot. Large vessels near heart and in lungs distended with white thrombi; inclosed part dark clots.

Bacterial investigations negative. One rabbit inoculated with bit of lung tissue in thigh remained well. Two mice inoculated with lung tissue died on the following day. Cultures from blood remained sterile. All but one culture from spleen and liver remained sterile. This contained a bacillus growing in the bottom of the liquid (butyricus ?).

In order to test the communicable character of this lung disease, two healthy pigs (Nos. 359, 360) were taken February 28 to the farm and penned with Nos. 408, 409, 410. At this time two of these three were already diseased, and No. 407 had already died in the same yard. On March 16, No. 408, having meanwhile succumbed to the disease, the remaining four were taken back to a clean pen on the experimental station. No. 409 died March 20, as already stated, and No. 359 was found dead March 24. It had been so weak as to be scarcely able to stand, although apparently free from cough. No skin lesions; superficial inguinal glands enlarged, pale, medullary portion dotted with blood-red points. A few slender fibrinous strings stretched across the coils of intestine. Stomach contracted, containing about 50^{cc} of a turbid yellow liquid. The walls covered with tenacious bile-stained mucus. Gall bladder contracted; contains an ascaris; one in cystic duct. Mucosa of large intestine dark colored. In cæcum four or five large ulcers, one surrounding base of valve. In another, about one-half inch across the necrotic center, projected like a button. In colon a large number of small ragged patches of a thin deposit which seems to be dead epithelium. *Thorax.*—Lungs do not collapse when thorax is opened. The major portion of both, excepting dorsal region, closely adherent to chest wall. The attachment being severed without difficulty, both pleural surfaces are found covered with a thin grayish deposit. Small quantity of turbid liquid present in pleural cavity; diaphragm entirely but loosely adherent to the pulmonary pleura. Portion of pericardium also adherent to pleura on the right side.

When the lungs were removed from thorax, all but the dorsal region found solidified. Even in this there were scattered hepatized lobules. The lung tissue varies in color from a pale to a bright red and resembles the diseased lungs already described. The smaller bronchi of the affected lobes were, as a rule, occluded with more or less consistent whitish plugs. Bronchial glands enlarged, cortex bright red.

Heart but slightly distended. Right ventricle filled with a firm washed clot; right auricle with a dark, soft clot. Left ventricle contains a small, dark clot; left auricle the same. This latter is dotted with closely-set, bright-red petechiæ, as if sprinkled with blood. Great vessels filled with dark clots.

Microscopic examination reveals a large number of swine plague bacteria in pleural exudate, immense numbers in the lung tissue. The whitish plugs in the small air tubes contain a moderate number mingled with other forms. Sections of the same lung tissue showed immense numbers of swine plague bacteria among the alveolar exudate. Bacilli were also present, but in small number. The following cultures were made: Of two beef infusion cultures from the pleural exudate one contained the swine plague bacteria only, the other in addition a streptococcus. With the pure culture two rabbits were inoculated by injecting one-fifth^{cc} beneath the skin of the thigh. One of them (small white) was dead next morning. A few ecchymoses in the subcutis at point of inoculation. The internal organs appeared unchanged. Both spleen and liver contained immense numbers of the injected bacteria—pure cultures of which were obtained from blood of heart and liver. The second rabbit was found dead on the third day. There was locally an extensive infiltration of the subcutis with superficial degeneration of thigh and contiguous abdominal muscles. Slight peritonitis. Hemorrhage into caudal lobe of right lung. Very few bacteria in spleen, liver, and heart's blood. A tube culture in gelatine shows the colonies in a few days.

Subsequent inoculations were made from cultures derived from the first rabbit Two rabbits were inoculated in the ear with a lancet dipped into the culture liquid. Both died on the third and fourth day after inoculation. The swine plague bacteria were found in the spleen of both.

Of two gelatine cultures from the pleural exudate both are impure, one containing besides the swine plague bacteria also the streptococcus, the other a chromogenous bacillus, described as *bacillus luteus* in the Second Annual Report of the Bureau (1885). Of three cultures from the spleen in beef infusion the *bacillus luteus* is present as well as the swine plague bacteria. This chromogenous organism had penetrated into the internal organs, the streptococcus being limited to the pleural cavity.

Pig No. 359, died March 24.

- pleural exudate
  - b. i. cult.
    - rabbit (subcutis) March 25 died March 28 (swine plague)
    - rabbit (subcutis) March 25 died March 26 (swine plague)
      - gel. cult. (liver)
        - b. i. cult. April 2
          - 2 rabbits (ear) April 4 died April 7, 8 (swine plague)
      - b. i. cult. blood
- spleen cults.
  - swine plague bacteria chromogene

No. 360 was exposed February 18 with pig No. 359, just described. After one month of exposure it became very weak and emaciated and kept on failing until it was found dead April 6. Its abdomen was very much distended; this distension had appeared before death. Superficial inguinal glands somewhat enlarged and congested. Peritonitis indicated by some reddish serum and by strings of fibrine stretched across coils of large intestine. The latter were greatly distended with gas and semi-liquid feces. Glands of meso-colon hemorrhagic. Lungs collapsed, quite red. Exostoses as large as marbles on four right lower ribs near cartilages. No other lesions observable. This animal, therefore, had not contracted the disease as observed in those animals with which it had been penned.

Another animal (No. 378) which had been growing poor for nearly a month and finally died was also affected with extensive hepatization of the lungs. The lesions observed were briefly as follows:

Scaly patches on the side of neck, on buttocks. About 25^{cc} of yellow serum in abdomen, a few strings of coagulated lymph on coils of intestines. Liver dark, resistant. Gall bladder distended with dark brownish bile. Stomach empty, bile-stained. Mucosa of intestinal tract dark, probably due to venous stasis; no ulceration. Heart large, flabby. Right heart filled with a very dark soft clot. Left auricle distended by a very firm white thrombus, left ventricle partly filled by a dark clot. All vessels leading to and from heart filled with moulds of dark coagulated blood. Lungs partly collapsed. Slight fibrous adhesion of each lung to chest wall. The cephalic and ventral lobes of each lung and the azygos lobe airless, solid, of a grayish-red, semi-translucent, or waxy appearance; bronchi plugged with a glairy mucus. At least one-half of the left principal lobe and one-third of the right hepatized, being the ventral portions. The disease was moving from the ventral to the dorsal side, *i. e.*, from below up when the animal is standing, the only portions not affected being those nearest the back-bone.

Although forms resembling swine plague bacteria were found on microscopic examination in the solidified portions, a rabbit inoculated on the ear did not succumb.

The microscopic examination of sections made from that portion of the lungs most recently affected and stained according to Gram gave some interesting results. Capillaries very much distended, with red corpuscles, so that alveolar walls appear very thick. Alveoli and smallest air tubes plugged with dense masses of cells, epitheleoid and round. In the alveoli are found chains of cocci (streptococcus) from five to twenty in a chain, winding in and out through the cell mass. They are approximately 1 micromillimeter long, slightly oval, and stain very deeply. In some groups of alveoli these streptococci are very numerous, in others they are few in number, or else replaced by another form consisting of minute bacilli in groups of few to many, usually within the protoplasm of the cells contained in the alveoli. These bacilli resemble tubercle bacilli very closely. In some alveoli they are exceedingly numerous. These two forms of bacteria, stained dark blue and strongly contrasting with the brown color of the cells (bismarck brown), were perhaps the only ones present, none others in sufficient numbers to be detected.

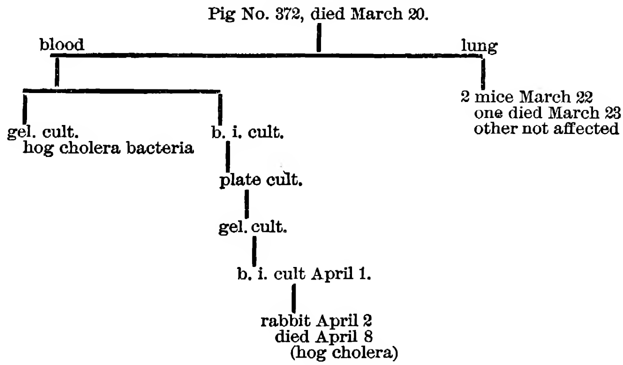
Cultures from blood of heart, spleen, and liver remained sterile.

No. 372 had been exposed in a pen, infected with hog cholera, to the lung disease. It had therefore been exposed to two different diseases. It began to grow weak and stupid, eating very little until death, on March 20, more than a month after the earliest symptoms of disease. This animal was found with extensive lung disease, while its internal organs contained hog cholera bacteria, as the following remarks indicate.

Animal with moderate amount of fat. Stomach bile-stained. Gall bladder filled with a thick prune-juice colored mass. Beginning sclerosis of liver. No intestinal lesions. *Lungs.*—Right ventral and left ventral lobes almost entirely solidified. Median ventral and cephalic border of right principal lobe solid, exceedingly hard to the touch; pleura covering it thickened. On section the lung tissue is found converted into a grayish, homogeneous, caseous mass. In left principal lobe a mass of tissue about 2 square inches in extent is solidified, some lobules being caseous, others still red. In the hepatized ventral lobes there are many lobules converted into a yellowish-white, homogeneous mass, almost cartilaginous. The small bronchi exude a glairy purulent mucus.

In the recent lesions bacteria few in number; in the caseous masses immense numbers, nature not determinable.

Liquid cultures from blood and spleen contain not swine plague but hog cholera bacteria. A gelatine culture from the blood contains the same bacteria. A rabbit inoculated subcutaneously with one-fourth^{cc} of a beef infusion culture died on the sixth day with greatly-enlarged spleen and coagulation necrosis of liver. In both organs the injected bacteria were present in large numbers. Of two mice inoculated with lung tissue one died next day; no examination made. Unfortunately no rabbit was inoculated from the lung tissue.



Pig No. 397 illustrates well the existence of two diseases in the same animal, the hog cholera bacteria being obtained from the spleen, the swine plague germs from the lungs. This animal was fed with the hepatized lung of pig No. 378 on March 24, and three days later with lung tissue from pig No. 359. In a week it became feeble, especially in the hind limbs, dull, without desire for food. April 13 diarrhea set in and it died next day. *Post-mortem* examination revealed extensive disease of the lungs and large intestine. The animal had contracted swine plague first; upon this disease hog cholera was grafted, which probably was the immediate cause of death.

Slight discoloration of skin on ventral aspect of body. Superficial inguinal glands enlarged, cortex infiltrated with blood, medulla dotted with petechiæ. Some fibrils of coagulated lymph across coils of intestines; small quantity of serum present in abdomen. Mesenteric glands very large, deep red. On section almost entirely infiltrated with blood, excepting a few patches of the medulla, which are homogeneous yellowish white; glands of meso-colon dark red. Spleen greatly engorged with blood, friable. In liver the connective tissue increased in quantity, parenchyma softened.

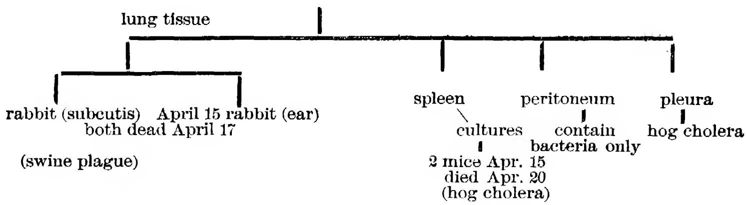
In thorax the right pulmonary pleura covered with a thin film of exudate. Considerable yellowish serum in both pleural sacs. The cephalic and ventral lobes and the ventral portion of principal lobe hepatized. The hepatization presents that peculiar grayish-mottled appearance on a deep-red ground; trachæ filled with whitish foam. *Digestive tract.*—Stomach filled with a turbid yellowish liquid, mucosa in general bile-stained, in fundus deeply reddened. In the large intestine the mucosa is uniformly and very densely sprinkled with dark-red points (extra-

vasated?). A dirty, yellowish, projecting ulcer on base of valve. Four or five of the same character, three-eighths to one-half inch across in cæcum and upper colon. In this animal the brain and spinal cord were laid bare. A few punctiform recent extravasations, chiefly in the white matter of the cerebellum.

With a bit of lung tissue two rabbits were inoculated—one beneath skin of thigh, another in the ear. Both were found dead within forty hours after inoculation; the bacteria of swine plague present in spleen and liver in large numbers, and obtained pure in cultures.

From the spleen, pleural, and peritoneal exudate the hog cholera bacteria were obtained pure. They were very scarce in the pleural exudate, however, as two out of three liquid cultures remained sterile. Two mice inoculated from the spleen culture were dead on the sixth day, both of hog cholera from the injected cultures.

Pig No, 397 died April 14.



Number 396 is another interesting case of lung disease complicated with hog cholera. This animal had been fed February 22 with portions of the spleen and large intestine of number 407, which has been dwelt upon in the preceding pages.

A few days after feeding it began to show signs of disease by growing weakness, especially marked in the hind limbs, no desire for food, and a slight diarrhea. A month after feeding, constipation set in, while the weakness of the hind limbs was very marked, bordering on paralysis, and anorexia continued. In the seventh week diarrhea again set in: the animal was unable to rise and died April 18, nearly two months after feeding. It was found with severe and extensive lesions of the lungs and large intestine. (See Plate IV.)

Digestive tract.—Stomach filled with food; normal. Large intestine, excepting rectum, ulcerated. Ulcers surrounding valve and forming a confluent mass in cæcum. In upper colon there are masses of exudate from one-eighth to one-fourth inch in diameter, at least 20 to a square inch (Plate IV, Fig. 2); lower down fewer in number. They are roundish, convex, brick-red masses which may be easily lifted from a raw, slightly depressed surface; every one is surrounded by an injected border. The mucosa itself is of a bluish-green color.

Lungs.—Right ventral lobe firmly and closely adherent to chest wall by a continuous sheet of fibrous tissue. This lobe feels like a bag filled with hard round bodies. On section it is found filled with whitish homogeneous masses resembling hard cheese (Plate IV, Fig. 1) embedded in bright-red, hepatized lung tissue. Left cephalic lobe in the same stage. The remainder of the left lung contains groups of lobules recently hepatized. Cavities of heart as in preceding cases.

Two rabbits and two mice inoculated in the ears with lung tissue without any result.

Gelatine cultures from pleura remained sterile. A culture from the spleen contained several forms, one of which resembled the hog cholera bacterium. After isolating this, two mice were inoculated from a pure culture. Both died in seven days with lesions characteristic of this disease.

The hog cholera germs were therefore present in this animal. The swine plague germ was not isolated, perhaps because the germs were too few. In such cases inoculation on the ears of rabbits seems to fail, since only a minimum quantity of lung tissue comes in contact with the puncture.

Whether the lung disease of this pig was contracted from the feeding must be determined from additional cases.

No. 392 died from swine plague, with a few doubtful hog cholera lesions and with hog cholera bacteria in the spleen. The remainder of the exposed animals had no swine plague lesions, but death was caused by acute hog cholera.*

The history of this animal is instructive, as it was inoculated from a culture of swine plague bacteria, which operation did not protect it from taking the disease subsequently. January 25, 1887, injected into each thigh about 2^{cc} from a beef

***The next case of swine plague in this pen died June 29, over two months after the death of No. 392.**

infusion peptone culture, one day old, of swine plague bacteria, obtained from an Iowa outbreak. For several days after the hind limbs were stiff, appetite poor, but the animal fully recovered. March 28, it was transferred with some others to a pen infected with swine plague and with hog cholera, as subsequent deaths showed. Two weeks after the animal began to fail and died April 20.

Skin along median line of abdomen deeply reddened. Subcutis over same region and sides, and subperitoneal tissue dotted with numerous pale-red spots of extravasation. Liver cirrhosed, contracted, pale. *Digestive tract.*—Mucosa along greater curvature of stomach dotted with small extravasations. Near cardiac orifice a small diverticulum was found about 1 inch in diameter. In it were from fifteen to twenty yellowish-white excrescences, round, removed with difficulty, and leaving a raw, depressed surface (diphtheritic). Cæcum and upper two-thirds of colon pigmented. In the latter the summits of about seven transverse ridges were covered with a very thin sheet of necrosed tissue.

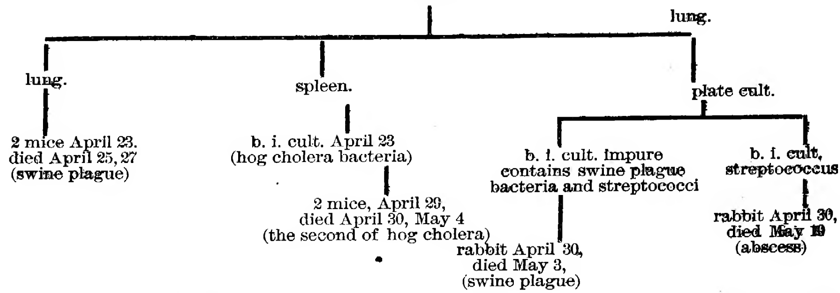
The lungs are the seat of recent and extensive disease. The ventral and cephalic lobe and ventral region of principal lobe of both lungs, as well as the small azygos lobe, are airless, of a deep red, mottled with pale-yellowish dots as in former cases; these dots correspond to the alveoli filled with exudate.

The disease is farthest advanced in the ventral and cephalic lobes. Here the lung tissue is interspersed with hard, yellowish-white nodules, from the size of a pin's head to that of a pea. Cover-glass preparations from the various diseased lobes show numerous forms of bacteria, no one predominating. The remaining portions of the lungs on the dorsal aspect are œdematous; a frothy liquid rapidly fills up the section. Scattered over the entire surface of both lungs are subpleural ecchymoses. These are characteristic of hog cholera in its most acute form.

The inoculations are given in the appended table and may be very briefly summarized. Plate cultures from lung tissue gave two forms, the bacteria of swine plague and streptococci, mentioned in former cases. A rabbit inoculated from a mixed culture of these two forms died in four days. The various cultures of internal organs of this animal contained the swine plague bacteria only. Another rabbit inoculated from a pure culture of the streptococcus died in twenty days from an abscess due to the inoculation. Two mice inoculated with lung tissue died. In one the bacteria of swine plague were found in large numbers. Of three cultures of the spleen of the pig only one became turbid. This contained hog-cholera bacteria only, as shown by the microscope and inoculation of mice.

This pig had therefore the bacteria of two diseases, the lung lesions belonging to one, the various hemorrhagic lesions, ecchymoses, etc., belonging to the other.

Pig No. 392.



During March and April a few animals placed in the infected pen in which the virus of both diseases had been scattered no longer took swine plague, but succumbed to hog cholera, as the following notes clearly indicate:

Pig No. 390, placed in the infected pen March 22, with pigs which subsequently died from lung disease as well as hog cholera. The animal died quite suddenly April 6. On examination the spleen was found very large, due to engorgement with blood. A moderate number of hog cholera bacteria present. Fundus of stomach considerably reddened. In the large intestine the mucosa is studded with irregular masses simulating ulcers; most of them seem to be adherent fecal masses. A few, when removed, leave a slightly depressed surface. Glands of meso-colon reddened; lungs normal, with the exception of a few scattered lobules, which are collapsed. No swine plague lesions observable.

The hog cholera bacteria were obtained in pure cultures from the spleen. Their specific nature was tested by inoculation into mice, both of which died on the fifth day with characteristic lesions.

Pig No. 386 was transferred to the infected pen at the same time. It became affected after a three weeks' stay in the infected pen, and died of hog cholera April 15. From the spleen the specific bacteria were obtained as pure cultures, and inoculation into mice produced the characteristic disease,

Pig No. 366 is another instructive case in which the two diseases were present. The animal had been put into a pen in which swine plague had to all appearance died out two months ago, but in which pigs were dying of hog cholera at intervals of a few weeks.

This animal had been inoculated into the lungs through the chest wall on October 30, 1886, with one-half^{cc} of liquid culture of swine plague bacteria. obtained originally from Sodorus, Ill. A pig inoculated subcutaneously at the same time died from its effects, but the former showed no signs of disease excepting a general unthrifty condition. The animal did not increase in size. As late as June 4, 1887, it was transferred to the pen above mentioned. It was injured by fighting with other pigs in the same pen June 21. Up to this time no change could be observed. It became very weak and died June 29, twenty-five days after exposure.

Autopsy immediately after death. Skin slightly reddened over pubic region; lymphatics but very slightly enlarged and congested; spleen enlarged, friable. In the cæcum and upper colon are from 12 to 15 small ulcers from one-quarter to one-eighth inch across. The mucosa itself is quite deeply congested.

The whole pleural surface of lungs lightly glued to chest wall; the attachment being readily severed, the pleura is found covered with a pale yellow exudate. The odor from the thorax is strongly putrefactive. The pericardium is thickened and everywhere adherent to the heart. The various lobes of the lungs are glued together by a scanty exudate. The ventral and cephalic lobe and the ventral (ventro-cephalic) portion of the principal lobe of each lung solidified. The remaining dorsal portion is dark red, hypostatic. Trachea and bronchi filled with yellowish foam.

The right cephalic and the ventral lobe have a yellowish-white appearance. On section the tissue is found transformed into a homogeneous mass cutting like dry cheese. These caseous masses are distributed as isolated nodules from the size of a pea to that of a bean, or else in the form of a thick net-work including dark-red, hepatized groups of lobules. The left cephalic lobe has not yet advanced to this caseous stage. In the left ventral lobe the process is begun as whitish arborescent lines with occluded bronchioles and alveoli. The thickened pericardium being removed, the surface of the heart was found covered by a firmly adherent deposit about 1 micromillimeter thick, villous, scraped away with difficulty. Over left ventricle a rather pale clot $\frac{1}{2}^{cm}$ thick.

These lesions indicated a severe form of swine plague. The intestinal ulcers pointed to the existence of hog cholera also. This was to be expected, since the pen was thoroughly infected with the latter disease. The bacteriological investigations demonstrated the presence of both micro-organisms, the bacteria of hog cholera in the spleen, those of swine plague in the lung tissue and pericardial cavity.

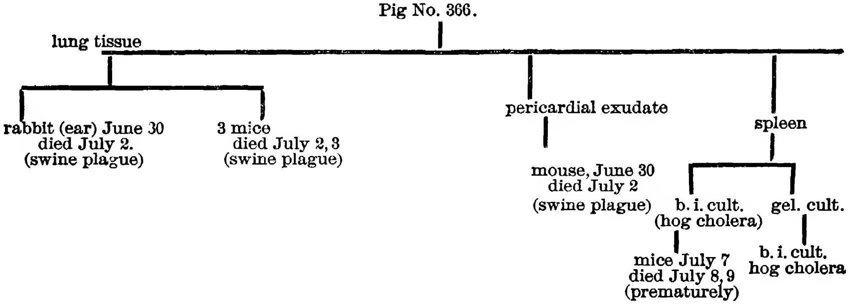
Cover-glass preparations from the hepatized lung tissue show immense numbers of bacteria, chiefly oval in form. A moderate number were found in the epicardial exudate. A rabbit and three mice were inoculated with a little semi-fluid matter scraped from a cut surface of the hepatized lung tissue, the former in the ear, the latter beneath the skin of the back; a fourth mouse was inoculated from the epicardial exudate. The rabbit died in forty-eight hours, apparently well a few hours before death. At the point of inoculation on both ears a small abscess, the pus containing long spore-bearing bacilli. Intense peritonitis. A thin, whitish, pasty layer covers the liver, spleen, and cæcum. The latter and portion of the colon covered thickly with subperitoneal hemorrhagic points and patches. Lungs œdematous. The peritoneal exudate contained immense numbers of oval bacteria. In the blood none could be found. A gelatine tube culture from the former and a beef infusion culture from the latter contained the characteristic swine plague bacteria. These had thus been isolated from the various putrefying forms by passing through the body of the rabbit.

The three mice inoculated from lung tissue died, two on the second and one on the third day. The latter, owing to the great heat, was already decomposed, having died during the night. The blood of the other two contained only the swine plague bacteria; roll cultures* made therefrom confirmed this. The fourth mouse

* Roll cultures are made by coating the inside of test tubes with gelatine which has been inoculated with bacteria to be studied. For a description of the method see *E. Esmarch, Zeitschrift für Hygiene I*, 293. This more convenient method had to be used, owing to the very high temperature of the laboratory in summer when all cultures in gelatine had to be kept in a refrigerator or "cold box." The ordinary plate cultures occupy too much space.

died next day. A gelatine and a liquid culture were both pure, containing only swine plague bacteria. At the same time the presence of these bacteria in the pericardial cavity of the pig was demonstrated by roll cultures. The presence of swine plague bacteria in both lungs and pericardium was thus amply proved. The latter was also invaded by other bacteria, a vibrio and a streptococcus being among the number.

Although microscopical examination failed to reveal any bacteria in the spleen of this animal the characteristic motile hog-cholera bacteria were obtained from it in both gelatine and liquid cultures. The colonies in the gelatine tube were very few in number. Two mice inoculated therefrom died rather prematurely in twenty-four and forty-eight hours, respectively, with the specific bacteria in the spleen.



Within several days of the death of this animal two pigs which had been placed in the same pen died of acute hog cholera, without any hepatization of the lungs.

Pig No. 414 was placed in the infected pen June 21, for the purpose of keeping up the disease of hog cholera, which was apparently dying out. The animal died July 6, after appearing dull for a few days. At the autopsy the lymphatic glands were found but slightly affected, spleen enlarged and very much congested. Lungs normal, excepting a few subpleural petechiæ. Cæcum and colon covered with a large number of ulcers, the mucosa of the latter intensely congested. The same was true of the greater curvature of stomach. Very few hog cholera bacteria in spleen. A pure culture was obtained therefrom.

Pig No. 416, put into the infected pen with No. 414, showed signs of disease July 4, and died on the same day. Skin of abdomen deeply reddened. Lymphatic glands with cortex hemorrhagic. Spleen very large and gorged with blood. Lungs and heart normal, with exception of a few subpleural ecchymoses. Numerous petechiæ on surface and in parenchyma of kidneys. Light hemorrhage into pelvis. Numerous subperitoneal ecchymoses on the large and the small intestines. Besides a general congestion of the mucosa of the latter there are a few small recent ulcers in cæcum and colon. Hog cholera bacteria quite numerous in cover-glass preparation from spleen. A pure culture obtained therefrom.

These three cases show that in the same pen two animals may be in contact with a third which has very extensive lung disease and not take the disease. It is barely probable that the period of exposure to the living animal, about eight days, was too brief a time for the transmission of the disease, or else the time elapsing between the exposure to this disease and the death of the animals from acute hog cholera was too short to allow the lung disease to make its appearance. We know as yet too little of this disease to offer anything but opinions concerning its origin and communicability.

The source of the lung disease in the first animal (No. 366) is likewise very puzzling, when we consider that a number of animals had died of hog cholera without any sign of lung disease.

BRIEF SUMMARY OF THE FACTS OBTAINED FROM THIS EPIZOOTIC.

In the fifteen animals which died there was extensive disease of the lungs, excepting in the first (No. 406), which was very likely a case of hog cholera. In most of these the pleura was also involved. In the earliest four cases, excluding the first (Nos. 403, 402, 405, 407), there were lesions of the large intestine, of the character of an exudate, of a partly croupous, partly diphtheritic character. In the two

succeeding (Nos. 408, 409) there were ulcerations, shallow but extensive, differing from the more penetrating hog cholera ulcers. In the remaining cases (excepting No. 396) the intestinal lesions consisted of extravasation, pigmentation, and ulcers which were very likely hog cholera ulcers. In No. 396 the croupous exudate preponderated.

As regards the bacteriological examination, the first case (No. 406) was not examined. Of the remaining fourteen, nine contained swine plague bacteria. These were obtained either directly from the pleural exudate or from rabbits and mice by inoculating them from the diseased lung tissue. Of those from which no swine plague bacteria were obtained it will be noticed that the lung disease was far advanced. The lung tissue was either converted *en masse* into a waxy homogeneous mass like cheese, or else the latter was sprinkled through the lung tissue in smaller masses. It must also be remembered that the absence of swine plague bacteria should not be inferred from the inoculation of a minute quantity of diseased lung tissue. It seems, however, very probable that in this advanced stage of degeneration the original pathogenic bacteria have been in greater part destroyed. In the later cases (Nos. 409, 372, 397, 396, 392, 366) hog cholera bacteria were also present, as determined by culture and inoculation experiments.

How can we interpret these results? Swine plague in a very acute form had attacked the herd, and in earlier cases this disease appeared in an acute uncomplicated form. This is indicated by the peculiar intestinal lesions (Nos. 403, 402, 405, 407). The two succeeding cases (Nos. 408, 409) were more advanced and less severe; the intestinal ulcers, shallow and broad, were the result of the diphtheritic exudate, which had passed away. The lung tissue was in part dead. In the remaining cases the characteristic swine plague lesions disappear from the intestine, and the lungs show a more advanced state of cheesy degeneration. The progress of the disease from a very acute to a chronic form, due most likely to a gradual degeneration of the virulence of the bacteria, is thus very well illustrated. In these later cases hog cholera bacteria are found in the spleen, and more rarely in the thoracic organs. The last cases died of acute hog cholera, with lungs normal. The exact part which the hog cholera bacteria played in the last swine-plague cases can not be formulated. It seems to me that they were an attenuated variety which found a place in the organisms because the latter were diseased, and that they grew in virulence until they were able to produce (a month later) the acute hemorrhagic form of this disease. There seems to be nothing so convincing of the gradual increase and decrease in the virulence of these two species of bacteria as the careful observation of a single epizootic from the beginning to the end. The mechanism of this change of virulence is important enough to warrant prolonged study.

There were a few cases that deserve special mention. Nos. 405 and 407 (Plates I, II) were perhaps the most typical of the acute, uncomplicated form of the disease. No. 410 is instructive, in that the disease seems to have spent its force chiefly upon the skin, leaving the lungs comparatively intact. The large size of this animal (the largest that died) may perhaps account for the shifting of the disease to the skin.

The introduction of hog cholera after the appearance of swine plague was most likely due to the case first reported in these pages (No. 406).

ATTEMPTS TO PRODUCE SWINE PLAGUE WITH PURE CULTURES.

A number of experiments were made which were designed to demonstrate, if possible, the specific nature of the bacteria obtained from diseased lungs. A reproduction of the disease after the introduction of the bacteria contained in pure cultures into the lung tissue itself must be regarded as conclusive evidence.

The following means of infection were tried:

(*a*) *By exposing pigs to a spray of culture liquid.*—February 17 Nos. 398, 400 were placed in a tight box, 3 by 4 by 2 feet, with a glass top. A spray was allowed to play into the box from an atomizer, the nozzle of which was introduced through a small hole in the side near the top of the box. The spray thus played across the top of the box, and was continued for two hours on two consecutive days, 300^{cc} of culture liquid being used each time. The culture was an infusion of beef, in which the swine plague bacteria (from an Iowa outbreak) had multiplied at 95° F. for two days. For several days after respiration was somewhat labored, and for nearly a week they ate very little. Subsequently, however, they fully recovered.

Nos. 393, 394 were exposed March 3 to a spray in the manner described. The culture was made in beef infusion and was one day old. The swine plague bacteria were from the Washington outbreak. The spraying was continued for one and one-fourth hours, several hundred cubic cemtimeters (about one-half pint) being used. No symptoms of lung disease followed the spraying. No. 393 was killed April 28, nearly two months later, and found perfectly sound. No. 394 was exposed to hog cholera April 30, and died of the acute hemorrhagic form of this disease May 17. The lungs were not hepatized but dotted with numerous subpleural petechiæ, characteristic of acute hog cholera.

Spraying and feeding cultures both had thus far proved ineffectual in reproducing any lesions in the lungs or the intestinal tracts. Other modes of introducing the virus were therefore tried.

(*b*) Two pigs (Nos. 383, 385), one of which had been fed with hog cholera and the other with swine plague cultures December 19, 1886, were perfectly well March 16, on which day 5^{cc} of a liquid culture of swine plague bacteria was injected into the trachea of each. Owing to the thick layers of fat in the neck, intratracheal injection could only be practiced by cutting down to the trachea, raising it with the finger, and then introducing the needle of the hypodermic syringe. After the operation the animals were dull and refused feed for one or two days; after that they were fairly well. The incisions meanwhile healed up. April 28, nearly one and one-half months after the inoculation, No. 385 was killed. The organs were normal; no lung disease manifest. No. 383 was exposed to hog cholera in an infected pen April 19, more than a month after the tracheal injection. It had been apparently well during this time. It died May 11 of acute hemorrhagic cholera. The autopsy notes being recorded elsewhere, it suffices to state that the lungs were covered, as is common in this disease, with large subpleural ecchymoses. There was no hepatization suggesting swine plague. On April 4 two pigs (Nos. 389, 401) received into the trachea each 5^{cc} of a beef infusion culture of swine plague bacteria about two days old. On the following day both were well. On April 27 No. 389 was killed and found healthy. No. 401, killed April 28, had likewise remained unaffected by the inoculation.

(*c*) At the same time, and with the same culture with which Nos. 383 and 385 were inoculated, two pigs (Nos. 352, 388) were inoculated directly into the lungs through the chest wall. No. 352 received $2\frac{1}{2}^{cc}$ into the right lung with a hypodermic syringe, the skin having been previously disinfected with a one-fifth per cent. solution of mercuric chloride. No. 388 received 5^{cc} in the same way. Both animals lost the use of their limbs, especially the posterior, within a day after the operation, remaining more or less paralyzed until the animals were killed, April 26. In the meantime they ate but little, while there were no symptoms directly referable to lung disease. Shortly before they were killed they had almost gained control of their limbs.

Autopsy of No. 352.—Right lung firmly adherent to chest wall and diaphragm by means of dense, fibrous tissue. Left lung adherent in a few places. On the lateral aspect of the left lung an oval mass as large as a small fist was found inseparably attached to it. This mass fluctuates, and when cut consists of a dense fibrous wall one-eighth inch thick, its inner surface of a deep red. The contents of this sac were of a putty-like consistency, greenish white, surrounded by a turbid fluid containing small flakes. The mass consisted of degenerated pus corpuscles, in which were disseminated the swine-plague bacteria in moderate number. The lung tissue was merely compressed by the tumor-like mass and not diseased. A gelatine tube culture inoculated from the caseous contents of the abscess contained an immense number of colonies of swine plague bacteria in each needle track. The absence of other micro-organisms proves that the abscess was the result of the presence of the injected bacteria. The other organs were normal. Cultures from the spleen remained sterile.

In No. 388 the pleuritic adhesions of the right lung are the same; the left lung free. Along the lateral edge of the principal lobe of the right lung are two tumors, one as large as a horse-chestnut, the other, contiguous with it, about the size of a marble. The walls and contents as in 352. A liquid and a gelatine tube culture from the contents contain the swine plague bacteria only. In the latter the colonies were innumerable in each needle track. The bacteria had therefore not only lived for forty-one days, but had multiplied enormously, causing the lesions described.

On January 25 Nos. 391 and 392 received into the subcutaneous tissue of the thighs 4^{cc} of a beef infusion peptone culture about twenty-four hours old. The swine plague bacteria were obtained from an Iowa outbreak reported in 1886.

No. 391 became lame soon after, probably from handling. Its appetite, poor at first, was restored after a week. February 18 it was killed, but no lesions were found, excepting circumscribed abscesses on the thighs at the points of inoculation.

No. 392 has been dwelt upon in the preceding pages. It did not show any symptoms referable to the inoculation. When exposed in an infected pen it died, being found with extensive disease of the lungs. Hence the inoculation was in no sense protective.

Pig No. 387, after a fast of more than twenty-four hours, was fed March 8, with about 200^{cc} of a beef infusion culture of swine plague bacteria, the culture being about three days in thermostat at 95° F. No disturbance whatever followed this feeding. The animal was subsequently exposed to hog cholera (April 19) and died of the acute form of this disease.

There is nothing to be added to the description given in the preceding report of the Bureau of the microscopic and biological char-

acters of the microbe of swine plague as obtained from the various outbreaks. There is, however, a very marked difference observable in their pathogenic effects. The organisms obtained from Sodorus and Geneseo, Ill., in the summer of 1886, both acted alike, while those from Iowa and from the District of Columbia, studied in the winter of 1887, also acted alike, but different from the two former. In the preceding report a number of cases are cited in which subcutaneous injections of cultures from the two first sources produced in pigs a very marked sclerosis of the liver, with pronounced icterus. Neither the organisms injected nor any other were found in the organs after death. Fowls were also killed by large doses and presented extensively local lesions. The organisms from the two latter sources had no effect upon pigs when injected hypodermically, even when very large doses were given. Fowls were likewise undisturbed after inoculation. On rabbits the difference was also noticeable. Inoculations of bacteria from the first class usually produced an extensive plastic peritonitis, lasting nearly a week before the animal succumbed. Inoculations of bacteria from the second class produced invariably a septicæmia, fatal within twenty-four to seventy-two hours. Peritonitis was either absent or barely manifested. Whether this difference is due to an inherent difference in the bacteria or to surrounding circumstances, such as temperature, attenuation due to cultivation, etc., can not be determined at present.

REMARKS ON THE CAUSATION OF SWINE PLAGUE.

The difficulties attending investigations of diseases which have their seat in the lungs, and which are presumed to be caused by specific bacteria, are due to the accidental presence of various other parasites. The air, as it is drawn into the lungs, carries with it the organisms suspended in it. From the mouth, which contains many bacteria, some may be carried accidentally into the air-tubes with the saliva or food.

When disease germs have obtained a foothold and produced a destruction of tissue or an infiltration by which the vitality of the tissue cells has been greatly reduced, other bacteria may also gain a foothold and multiply, although this may have been impossible in a normal lung.

In examining sections of diseased lung tissue different forms were found, no two lungs showing the same micro-organisms. Among those which were found several times was a streptococcus, appearing in the alveoli in the form of long chains. These chains were imbedded in the mass of cells which filled the alveoli. In some sections groups of cocci, in others masses or bacilli were observed. Finally in the early stages bacteria were very scarce, and if the disease ran a very rapid course only the bacteria, which we regard as the cause of this disease, were present in large numbers. When portions of the lung tissue died and then appeared as homogeneous masses imbedded in diseased but still living tissue, bacteria of every description could be observed in these dead masses and the lung itself usually emitted a putrefactive odor.

In the interpretation of these sections under the microscope we must be very careful in assigning any particular rôle to the bacteria present. Most of them are there because of the previously existing disease, which, so to speak, prepared the soil for them. In the second

place the bacteria, which are in reality the cause of the disease, may be present only at a certain stage of the disease, being subsequently destroyed by the cells as the lungs heal, or giving away to accidental forms as the disease progresses. We must bear in mind with reference to the second alternative that pathogenic bacteria must suffer by the gradual changes which they themselves induce. Thus in the early stages they undoubtedly live and multiply in the exudate which is contained in the alveoli. When this becomes more and more consolidated, and as the ultimate bronchi are occluded by exudate, the bacteria are being deprived of nutriment and oxygen. The tissue dies, and with it the bacteria originally causing its death; other bacteria more adapted to the conditions now prevailing get a foothold, until the entire lung becomes a prey to many kinds of bacteria.

A well-known illustration may be cited in support of these assertions. The tubercle bacilli, which may be seen in sections of young tubercles, can not, as a rule, be found in the caseous mass which forms later on in the center of the enlarging tubercle. Inoculations of blood serum with such material are apt to prove failures, and if it were not that inoculation into guinea pigs is almost invariably successful we might presume that the bacilli had perished. The fact is, the bacilli, finding no suitable conditions of growth in the caseous mass, would perish if it were not that they have the capacity to form spores under such circumstances. These spores, which may fail to germinate on blood serum, find a more suitable medium in guinea pigs, where they soon give rise to a generalized tuberculosis.

The problem to be solved, therefore, was to isolate the specific bacteria which are the cause of the disease from the rest. The method pursued was to introduce minute bits of diseased lung tissue beneath the skin of rabbits and mice. If the specific bacteria are present they will in all probability cause the death of the inoculated animals. They will then be found in one or more of the internal organs, from which they can be obtained free from the other bacteria. These will remain restricted to the place where they were deposited. This method of obtaining disease germs has been used by other investigators, more particularly by Schütz, in the study of swine plague in Germany, and more recently in investigations of infectious pneumonia in horses. A résumé of this work on the bacterium causing swine plague has been given in the preceding report of the Bureau in connection with the preliminary investigations made last year of American swine plague. The facts in the case are briefly as follows: It was found that in the majority of cases, when bits of diseased lung tissue were placed beneath the skin of rabbits and mice (or simply rubbed into any slight prick made on the ear with a lancet), a septicæmia appeared with which the bacteria described in the preceding report were always and exclusively associated. Rabbits are more susceptible than mice, and die in from one to four days after inoculation. By this means pure cultures of the same bacteria were obtained from most of the cases reported in the preceding pages. This was therefore the only microbe present which was capable of destroying the smaller experimental animals.

It may be argued that bacteria obtained in this way may be accidentally present in the diseased lung tissue, and that the bacteria which are the real cause may not produce any disease whatever in the experimental animals. Without entering at present into any detailed statement of the other arguments in favor of this bacterium as the cause of swine plague we may state that most of the bacteria

which produce diseases in the higher animals are fatal to mice or rabbits or guinea pigs, or all three. We need only to mention anthrax, black quarter, tuberculosis, fowl cholera, *rouget* among swine, hog cholera, glanders, the German swine plague, and infectious pneumonia in horses. And the converse may also be assumed as true that any bacteria which are harmless to these experimental animals are, as a rule, not the cause of virulent diseases among higher animals.

In one of the cases given in the preceding pages in which the disease had involved the pleura, pure cultures of this bacterium were obtained from pleural effusion, while it was obtained from the lung tissue by inoculating rabbits with bits of the tissue as above described. This case, therefore, is worth a host of negative ones, for we can not but believe that if the disease enters a closed cavity, like that of the thorax, the bacterium there found exclusively is the cause of the process. In a subsequent case the same organism was obtained from the diseased pleura, but mingled with two others, a chromogenous bacillus found in cases of hog cholera several years ago, entirely harmless, and the streptococcus already mentioned. The lungs in this case emitted an unpleasant odor.

The streptococcus was isolated after much difficulty and more carefully examined. It requires a higher temperature for its growth on gelatine, so that plates made during the winter months were as a rule unsuccessful. It grows quite well in nutrient gelatine at a temperature of 75° to 80° F. The colonies in the depth of the gelatine are spherical, whitish; the surface growth is very scanty. In liquids the growth is quite peculiar. The culture liquid remains entirely clear, but a number of white flakes appear usually in the bottom of the tube, occasionally on its side when the tube remains in an inclined position. These flakes do not grow larger than 1^{mm} to 2^{mm} in diameter. Under the microscope they are seen to consist of masses of interlacing chains of cocci. This accounts for the permanently limpid condition of the culture fluid. It serves at the same time as an important aid in determining the purity of a culture. This description applies to beef infusion. When 1 per cent. peptone is added the flakes are much larger and the deposit becomes quite abundant. The liquid remains clear. They do not grow on potatoes. When milk is inoculated its appearance remains unchanged.

In sections of the lung tissue they are brought out very neatly by Gram's method, and the chains can be readily followed by focusing as they wind through the cellular exudate in the alveoli. This property of retaining a deep-blue color after the application of iodine solution is retained by the cocci when under cultivation. The individual cocci are slightly oval, the longer diameter being about 8 micromillimeters. They strikingly resemble the bacteria causing swine plague in exhibiting two stained extremities joined together by a median, unstained, very narrow zone. They are, however, very readily distinguished from swine plague bacteria. The latter are much smaller, do not retain the stain when treated according to Gram's method, and never appear in chains. The uncolored zone may be looked upon as a stage in the process of division of a single coccus into two cocci.

The pathogenic power of this organism was tested by inoculating one-twelfth^{cc} of a pure, liquid culture subcutaneously into two rabbits and two mice. Both mice were found dead on the morning of the second day. One, being partially decomposed owing to the heat during the night, was not examined. In the other there was at the point of inoculation a slight, reddish, serous infiltration containing numerous streptococci. There were a moderate number in the spleen and blood from the heart. In a gelatine tube culture made from the latter a number of colonies of streptococci appeared after a few days. In the beef infusion tube a small number of minute white masses appeared, after three days floating, in a perfectly limpid liquid. These were made up of interlacing chains of cocci. The two rabbits remained well. When killed after fifteen days one of them was found infested with cysticerci. There was a small, softened, whitish mass in the muscles of the thigh at the place of inoculation. The second rabbit, perfectly well up to the twenty-fourth day, was then inoculated on both ears with a bit of lung tissue from swine plague, to which it succumbed in a few days.

Cultures of this microbe were injected beneath the skin, into the thorax, and into the trachea of pigs without causing any disturbance. It therefore had but slight pathogenic properties, and no further attention was paid to it. It may be that it is the streptococcus pyogenes found occasionally in abscesses.

In some cases when the powers of life are much reduced and the destruction of the lungs is far advanced, the same bacteria which are found entering the pleural cavity may appear in the blood, spleen, and other organs. This was true of No. 392, in which the chromogene there mentioned was found in the spleen as well as in the pleural cavity. In a considerable percentage of the cases given, anaërobic bacilli were found in the cultures from the internal organs. These microbes may have gained entrance by way of the digestive tract (liver) or the diseased lungs in the form of spores and developed under the peculiarly favorable conditions. Death usually takes place by a paralysis of the respiratory function (asphyxia); the right ventricle and large vessels are filled with large thrombi. The system being thus slowly but completely deprived of its oxygen anaërobic bacteria may multiply and appear in cultures. They seem to be butyric bacilli, judging from the odor emitted by the cultures. These bacilli carry on a feeble existence in the lowest strata of liquid cultures and die out very soon.

The presence of the bacterium of swine plague in animals having hepatized lungs has been proved in several outbreaks, some of which have been dwelt upon in the preceding report of the Bureau. They may be summarized briefly as follows: The specific microbe was obtained from the spleen at Geneseo, Ill., July, 1886; from the pleural cavity (as a pure culture) of a pig at Sodorus, Ill., September, 1886; from lung tissue (by inoculation into rabbits) sent from Iowa, January, 1887; from a considerable number of cases fully described in this report, studied at the experiment station of the Bureau during the winter of 1887. In all of these cases hepatization of the lungs was present. This organism has never been obtained in cultures from several hundred cases of hog cholera in which extensive lung disease was absent.

The final proof of the causal relation between a given microbe and a disease having definite pathological characters can only be brought by actually reproducing the disease in healthy animals with pure cultures of the given microbe.

In the experiments made with this in view, and detailed in the preceding pages, cultures were introduced into the lungs through the trachea, and pigs were exposed to the spray of liquid cultures. In none of these experiments was the disease reproduced. In two cases, however, the injection of a few c. c. of culture liquid into the thorax produced large abcesses, the contained pus being of a semi-solid caseous consistence. The presence of the injected bacteria only in immense numbers proved them to be the cause of these changes. These two cases are by no means positive, but very presumptive evidence that the microbe under consideration is the true cause of swine plague.

There are several reasons why this microbe may not produce the disease when introduced into the lungs by way of the trachea. There may be a rapid attenuation in artificial cultures. But more plausible than this is the theory that in this, as in perhaps the great majority of lung diseases, the specific bacteria can not gain a foothold unless there be some disease already existing which has been produced by exposure or parasites, or both. It is a well-known fact that it is more difficult to produce diseases of a general character like anthrax by introducing virus through the trachea into healthy lungs than by subcutaneous inoculation, as the air passages are well provided with means for resisting the entrance of foreign particles.

Schütz, in his investigations of swine plague in Germany, was able to reproduce the disease by exposing pigs to the spray from culture liquids simply because he had a more virulent microbe to deal with. He produced, for example, a general septicæmia in pigs by the subcutaneous injection of cultures. Numerous subcutaneous inoculations made with cultures at the experiment station of the Bureau have in no case produced septicæmia. We must not expect any microbe to grow in the blood and internal organs of healthy inoculated animals when it appears there only in rare instances and in very few numbers in animals spontaneously affected with the specific lung disease, and moreover with the whole system greatly debilitated thereby. In his investigations of infectious pneumonia in horses Schütz* reproduced the disease with cultures of the specific microbe by direct injection of culture liquid into the lungs through the walls of the thorax. In a second experiment made by spraying a large quantity of culture liquid through a tracheotomy tube directly into the bronchi the lesions found on killing the animal proved less positive.

Careful observations of the lungs in pigs which have died of hog cholera, of those which have been killed, apparently in good health, and of those of very young animals which died of exposure or lung worms, lead us to conclude that unless the bacteria of swine plague happen to be of exceptional virulence, some slight lung disease, such as atelectasis or lobular broncho-pneumonia, must furnish the starting point from which the remainder of the lung tissue is attacked. In the preceding article on hog cholera this has been dwelt upon more at length. There it has been shown that in at least one season of the year, the fall, collapse and lobular pneumonia, lung worms, and bronchitis are very common in young animals. When an epizootic is very severe, and such seem to be quite rare, the healthy lungs of even adult animals may be attacked. Of this state of affairs the epizootic described furnishes a good illustration.

SOME OBSERVATIONS ON THE GENERAL CHARACTER OF SWINE PLAGUE.

To understand the character of this disease, its mode of invasion and particular seat, a brief description of the pig's lung is necessary:

When inflated through the trachea after the sternum is removed, and while it is still in its natural position in the thoracic cavity, it will be observed that the surface resting against the ribs laterally is the most extensive. That surface resting upon the diaphragm comes next, while the ventral aspect is the smallest.

The right lung is made up of four lobes; the left has only three. (In text-books on anatomy the left lung is considered as being made up of only two.)

In both there is a large principal lobe resting upon the diaphragm and against the adjacent thoracic wall. This lobe forms the major part of each lung. The remainder, occupying the anterior (or cephalic) portion of the cavity, is made up of two small lobes, one extending ventrally (or downward in the standing position of the animal) and in the expanded state covering the heart laterally, the other extending towards the head and overlapping the base of the heart. These small lobes may be denominated the ventral and cephalic lobes, respectively. The right cephalic lobe is longer and more distinct from the ventral lobe than the corresponding left cephalic. Wedged in between the two principal lobes and resting on the diaphragm is a small lobe, pyramidal, belonging to the right lung (azygos lobe). This lobe rests on the left against the mediastinal membrane, and on the right it is separated from the right principal lobe by a fold of the pleura passing from the ventral ab-

* Die Ursache der Brustseuche der Pferde. Archiv für pathologische Anatomie (1887) CVII, p. 356. Archiv für wissenschaftliche und praktische Thierheilkunde (1887) XIII, p. 28.

dominal wall to inclose the inferior vena cava. This small lobe is almost completely shut off, therefore, from the other lobes by folds of the pleura.

When the trachea and its branches have been examined it is easier to understand this division into lobes. The trachea divides in the thorax into two principal branches or bronchi. These bronchi pass into the principal lobes, straight to the caudal border, giving off a number of small branches along their course. Very near the place of bifurcation the left bronchus gives off a large branch, which ramifies in the substance of the left ventral lobe. From this branch another goes to the cephalic lobe. In some lungs the branches for these two lobes arise together by a very short, scarcely perceptible trunk, and are of nearly equal size. The bronchial supply of the right lung differs materially from that of the left. About 3^{cm} from the bifurcation the trachea gives off a small bronchus, which supplies the right cephalic lobe exclusively. At the bifurcation the right bronchus sends a branch to the ventral lobe. A short distance from this the same bronchus sends a short branch to the small median or azygos lobe.

These brief remarks will be sufficient to give a general idea of the gross anatomy of the pig's lung. The manner in which the air tubes branch gives us a clue as regards the invasion of the disease itself. The bacterial virus entering the trachea first enters the air tubes supplying the ventral and cephalic lobes. These become consolidated. It then enters the air tube of the small median lobe, and then it invades the smaller branches of the principal lobe nearest the trachea. This is the farthest point to which we have seen the disease advance before the animal succumbed.

A careful inspection of the autopsy notes will show that this is the course of the invasion. No case has yet come to our notice in which the ventral lobes were normal, while the principal lobe was in part consolidated. In many of the cases the disease was cut short by the death of the animal before it had reached the principal lobe. It would be interesting to know whether or not the right cephalic lobe, which is the first to receive its bronchus, and moreover directly from the trachea, is first affected. It is difficult to decide this matter, as the animals do not die until the disease has made some headway. It is a matter of common observation that in collapse and catarrhal conditions the ventral lobes are chiefly involved. But there is another peculiar feature which will explain the location of the disease much better. When the lungs are taken from the thorax and held in the position which they occupy in the standing animal, the line of demarcation between the diseased and healthy lung tissue is nearly horizontal, all below this being consolidated. If gravity has any influence upon the virus in selecting its place of attack, we should expect to find the ventral lobes first involved, next the cephalic, and lastly the ventral portions of the principal lobes and the median lobe. This course is nearly the same as that given above when the bronchial supply was discussed. We have not yet seen lungs in which the uppermost portion of the principal lobes, *i. e.*, on either side of the vertebral column, was involved. When the disease progresses it is upward, *i. e.*, towards the back-bone of the animal, invading the still spongy tissue by lobules and groups of lobules.

If we put together the facts brought out in the preceding pages we can construct a theory as to the manner in which the virus enters the lungs. The course of the invasion shows that the virus is not inhaled with the air, that it is not suspended in the air as a living germ, otherwise it would be difficult to explain the peculiar localization and the slowly progressive nature of the disease. A virus imbedded in some liquid vehicle will perhaps explain all the facts most satisfactorily. Its slow movement from bronchus to bronchus, its limitation by gravity to the most dependent portions of the lungs at

first, and its extension upwards as it gains upon the vitality of the lung tissue, all accord with this theory. At the same time it harmonizes with the fact that the microbe causing the disease can not survive drying for even a single day.

In this disease the lungs are primarily the seat of the virus, and in them the greatest changes are observable. The lesions are those of a broncho-pneumonia. The pleura is secondarily involved over the seat of the disease when this extends to the surface of the lungs. The great variety in the appearance and extent of the lesions as manifested in different cases may be brought together under a few heads for description.

The most severe types of disease are encountered at the beginning of an epidemic, and may be conveniently denominated acute. Plates I and II are illustrations made from the right lung of pig No. 407, described in the preceding pages. As may be seen, there is extensive pleurisy accompanying the pneumonia. The disease is characterized by a solidification of the ventral, cephalic, and median lobes, and a portion of the principal lobe, usually of both lungs. The diseased lobes are moderately expanded, so that the thorax seems almost filled up with lung tissue when the sternum is removed. The hepatized portion has a bright blood-red color, when viewed from the surface, as well as on section. The surface in many cases has a peculiar mottled aspect, shown in Plate III, Fig. 2. The bright-red ground is dotted with closely set, grayish-yellow points, arranged quite regularly in groups of four, occasionally of three. These points are not sharply defined, but hazy. When examined with a lens this haziness is well marked. This grayish mottling does not appear everywhere on the diseased lung, but only upon some lobes, and then with striking clearness and uniformity. These points no doubt are the terminal air sacs, or infundibula distended with the cellular exudate. The more leucocytes in the exudate the whiter the injection will appear through the translucent pleura. The occlusion of the air cells and bronchi by catarrhal products and the mottling due to it may, however, be seen in lungs free from swine plague bacteria (simple broncho-pneumonia). The bacteria are found imbedded in the cellular masses, which occlude the alveoli. The disease involves the terminal air tubes, as they are frequently found packed with cells. The larger bronchioles and bronchi are the seat of catarrhal changes. The lumen of the tubes is filled with a muco-purulent secretion, usually containing large numbers of bacteria.

The foregoing may be regarded as the early stages of the disease proper. When the invasion is thus extensive and takes place suddenly, the animal speedily succumbs before the disease has had the opportunity of entering upon the more advanced stages. But in perhaps the majority of animals the disease progresses very slowly. It may be that only the ventral lobes are attacked at first, and then only in certain limited areas. The surrounding tissue becomes hyperæmic and often consolidated. The areas first attacked become converted into homogeneous greenish or yellowish-white masses, sharply defined from the surrounding tissue. They cut like ordinary hard cheese, and on microscopic examination are found to be made up of dead lymphoid cells and bacteria of all kinds. The process of caseation is without doubt caused by the packing of the respiratory tissue with cells, by which the capillaries are compressed and all food supply cut off. The caseous foci vary from the size of a small pea to that of a marble or horse-chestnut. (Plate IV, Fig. 1.) They are

usually round, rarely irregularly elongated. They are occasionally present in such numbers that the affected lobe feels like a bag filled with small marbles. It is highly probable that now and then the pathologic process may go a step farther. The caseous mass may be separated by secondary suppurative processes from the living tissue, soften, and be discharged through a bronchus, leaving an irregular cavity. We have seen but once what appeared to be cavities in a piece of lung sent to us from the west.

A few lungs have come to our notice in which this process of slow necrosis was not limited to groups of a few or more lobules, but had involved the entire lobe uniformly. The tissue was completely airless and bloodless, of a homogeneous consistency, cutting like cheese, yellowish, with a semi-translucent, waxy luster.

In distinction from the acute type of this disease, the process ending in caseation may be regarded as essentially slow and chronic. It may either be due to a diminished virulence of the bacteria or to a greater resistance on the part of the lung tissue. The former supposition seems to us nearer the truth, and there is much other evidence which points to a rapid attenuation of this specific virus.

The pathological process may be briefly summarized as follows: The bacteria, which have somehow entered the air tubes, begin their destructive activity in the alveoli and ultimate bronchi. A copious exudate, consisting chiefly of desquamated epithelium and round cells or leucocytes, fills them completely. Although the bacteria are finally destroyed by the exudate, the latter impairs by pressure the nutrition of the lung tissue proper, and the whole becomes involved in necrosis. The covering of the lungs is secondarily affected. In acute cases the pleura of the hepatized lobes may be covered with a fibrinous exudate of a spongy texture, containing a considerable number of round cells and bacteria. It may become several millimeters thick, and tends to unite the lungs with the chest wall. The adhesion is at first broken without injury to the lung substance and is quite easily peeled from the pleura itself, as shown in Plate I. Not infrequently the diaphragm is more or less firmly glued to the base of the principal lobe when that is diseased, as is shown in Plate II. The pulmonary pleura and adherent costal pleura may sometimes form cavities between them, containing a yellowish-white, very turbid liquid crowded with bacteria. The adhesions are sometimes very close, the costal pleura having its minute vessels much injected at such spots. In older cases there are bands of fibers, of various lengths and density, bringing about the adhesion. In most cases the pleuritis is dry, with no adhesions. Over the dead lung tissue the pleura may be opaque and thickened or quite transparent, as in health. In several cases in which gangrenous processes were indicated by putrid odors, a generalized pleurisy was found gluing the entire lungs to the chest wall by means of a pasty exudate. In this various bacteria were found, which, very likely, had a share in the inflammatory changes. The pericardium occasionally is involved with the pleura and is subject to similar changes. In but one of the cases (No. 366) thus far examined was the epicardium covered with a fibrinous exudate.

Intestinal lesions.—In the severe types of this disease, there are very extensive lesions of the large intestine. These on superficial examination resemble those of hog cholera so much that this similarity alone may have prevented the separation of these two diseases by pathologists who have studied them very carefully.

Although the lesions seemed to us at first sight different from the ulcerations found in hog cholera, yet it was only after the futile search for the specific bacterium of this disease in the spleen of the affected animals that we ventured to consider them as something entirely different from the lesions produced by that disease.

In the following pages we shall try to state as clearly as possible the difference between the appearance presented by the large intestine in hog cholera and in swine plague.

Croupous and diphtheritic lesions.—The mucous membrane is dotted by a large number of closely set, convex, circular masses of a yellowish tint. These are rarely larger than one-eighth to one-fourth inch in diameter. They can be readily lifted away from the membrane, leaving a slightly depressed, raw surface. This mass which has exuded from the membrane is tough, evidently made up of a fibrinous coagulum. It is very easily mistaken for an ulcer when the examination is carelessly made. The hog-cholera ulcer, it will be remembered, is a circumscribed death or necrosis of the mucous membrane. The hole thus made is occupied by a soft, granular matter, in some cases projecting above the surface like a button, which is scraped away with some difficulty, leaving an irregular excavation. Very rarely the ulcers are flat, button-like masses, presenting concentric bands of a dirty yellow and black. They are then made up of hard, tough, homogeneous, whitish tissue, extending at times as a neoplasm through the entire intestinal wall to the peritoneum. These ulcers vary much in size, from a pins' head to an inch or more in diameter. The lesions found in swine plague are therefore different in that they consist of masses of exudate, either isolated or running together into large patches of variable size and thickness. The rectum (rarely diseased in hog cholera) is quite frequently involved with the colon. In some cases a continuous sheet of deposit covers the mucosa entirely. This may adhere with considerable tenacity, or it may be removed simply by the stroke of the scalpel, or it may not be attached, but appear as a part of the intestinal contents. It then consists of small lumps stained with bile and feces and easily overlooked. Sections of the intestinal wall show the exudate to consist of mesh-work which may or may not inclose leucocytes. When the inflammation is very severe the membrane beneath the exudate is liable to necrosis, and the process must then be regarded as diphtheritic. It is probabale that in all cases the epithelium is destroyed in order to give rise to the exudate, and all varieties of lesions, from the simply croupous to the diphtheritic, are to be met with, depending on the quantity and quality (or virulence) of the infectious agent. The anatomical distinction between croupous and diphtheritic lesions seem at least in this disease to be simply due to a more or less intense action of the same cause. In diphtheritic conditions therefore, ulcers may subsequently appear. Our observations on this stage of the process are too few to warrant any conclusions. Once or twice ulcers were seen which differed from hog cholera ulcers in being perfectly round, as if punched out of the membrane, from one-eighth to three-eighths of an inch in diameter. The bottom of the ulcers was concealed by a thin, creamy deposit, the border slightly thickened and very red. There was no adherent slough. Some of the ulcers corresponded with the mouths of the flask-shaped mucous glands.

The exciting cause seems to attack the membrane from the surface, for the submucous tissue is not infiltrated with cells to any

extent. In hog cholera very extensive infiltration quite invariably accompanied the ulceration, so as to make the intestinal wall very brittle.

In another case the mucous membrane appeared as if gnawed or eaten away in large patches. The diphtheritic deposit and subjacent membrane in state of necrosis had very likely been shed as a slough, leaving the ragged, depressed surface.

The pathological process in the large intestine is distinctly exudative, diphtheritic in swine plague; in hog cholera it is essentially necrotic or ulcerative. In the latter the virus may act not only from the intestine but also from the blood. In the former it perhaps never acts from the blood, but only from the intestine.

The lesions of the intestinal tract are always co-existent with the specific broncho-pneumonia and without doubt secondary to it, because we frequently have encountered lung disease without intestinal disease. The origin of the latter may be accounted for in two ways. The virus enters the digestive and the respiratory tract at the same time, or else it gains a foothold in the lungs first and thence reaches the intestines. This is possible, for the bronchi are filled with bacteria imbedded in a large quantity of purulent mucus, which has come from the diseased alveoli and bronchioles. They may be coughed up into the mouth and swallowed and lodge at first in the mucous glands of the large intestines, where they are well protected while multiplying. The remainder of the mucous membrane may then be attacked if the animal be weak or the virus especially active. The simultaneous attack of lungs and large intestine is perhaps very rare. Feeding large quantities of culture liquid and of rabbits which have died after inoculation does not produce any lesions whatever. We must therefore consider the lungs the most vulnerable and the intestines only secondarily so. This view is supported by the fact that in the early and most pronounced cases of the Washington outbreak the intestinal lesions were very marked, but disappeared in the progress of the disease. The virus, at first very powerful, became slowly attenuated, being unable to attack the mucous membrane of the intestines and therefore confined to the lung tissue. Intestinal lesions are thus always associated with the severest lung disease, which in turn is characterized by an abundant muco-purulent secretion in the air passage.

Diagnosis.—The disease just described can not fail to be recognized, as it seems to be the only severe disease of the lungs among swine of which we have any knowledge. That exposure may bring on croupous pneumonia we do not deny; but the character of the ordinary croupous pneumonia among animals is such that it can be readily distinguished from the irregular atypical infectious broncho-pneumonia which we have just outlined. It is barely possible, however, that the disease may be confounded with other lesions which we have met now and then in *post-mortem* examinations.

The small ventral lobes which hang down on either side of the heart are very frequently collapsed (atelectasis). The affected lobe is small, of a bright red, soft to the touch, but without crepitation. The tissue is not diseased, as may be seen on microscopical examination. This condition is the result of a plugging of the bronchus supplying the lobe with catarrhal products. The air can not enter the tube, and all the tissue supplied by it remains collapsed. Groups of lobules, permanently collapsed, may be found in other portions of the lungs.

A lobular broncho-pneumonia simulating infectious pneumonia very closely is not infrequently found in young pigs. It is described on p. 485. It seems to follow collapse.

Lung worms (*Strongylus paradoxus.**)—Are frequently found in the fall and winter. They first appear in the extreme end of one of the large bronchi, *i. e.*, in the caudal tip of a principal lobe. Here they may be detected as small, hard nodules, not larger than a small pea. The lung tissue around them may be hyperæmic, or perhaps in a state of hepatization. The presence of the worms will in all cases explain the lesions.

More advanced changes are well illustrated by a case which came under our observation recently. Each principal lobe contained four masses about three-fourths of an inch in diameter and very hard to the touch. The cut surface was coarsely granular, the granules yellowish, imbedded in a pale red parenchyma, and probably representing plugs in the smallest air tubes and alveoli. The trachea and bronchi contained large quantities of gelatinous mucus. The bronchi leading to the hepatized regions were completely occluded with lung worms. There was not pleuritis.

In hog cholera the lung lesions are quite insignificant compared with those of other organs. In the acute type there is usually a hemorrhagic condition. The entire surface is dotted with subpleural blood extravasations. On section the lung tissue itself is found to contain these hemorrhagic foci. Excepting the occlusion of a few alveoli here and there with blood, there is no inflammation or hepatization perceptible in any part of the lung tissue.

In chronic cases of hog cholera these hemorrhages either never take place or else they are speedily absorbed, for the lungs are, as a rule, healthy, if we except the collapse of the small ventral lobes now and then encountered as above described.

When the sternum of a diseased animal is removed the ventral lobes which overlap the apex of the heart only during a full inspiration do not collapse and drop out of sight into the thorax, as in the normal lung, but they stand up over the heart as two solid masses, of a deep red, mottled with yellowish points, or more grayish, according to the stage of the disease. If these lobes are normal the disease, as a rule, does not exist in the remainder of the lung tissue. Frequently they are glued to the walls of the thorax and the pericardium.

The appearance of the lungs will thus lead to an easy diagnosis of swine plague as distinguished from hog cholera. The intestinal lesions which accompany swine plague in its most severe forms are not so easily differentiated from lesions produced by hog cholera, but a careful attention to descriptions given in the foregoing pages will solve this difficulty in most cases. The disease of the large intestine in swine plague is essentially exudative. Necrosis of the superficial layer of the mucous membrane is secondary, the resulting ulcers superficial. In hog cholera the lesions are at first either hemorrhagic or necrotic (ulcerative), or both. There is little or no exudate preceding the stage of ulceration.

SUGGESTIONS AS TO THE MEANS OF PREVENTING THE SPREAD OF SWINE PLAGUE.

Experiments with the microbe of this disease have shown that it has very feeble powers of resistance to external agencies. It is killed

* See p. 282 of the Report of the Bureau of Animal Industry for 1885.

by drying within twenty-four to forty-eight hours, and it is speedily destroyed in water. Its life in the soil is no doubt very limited for these reasons. Moreover, it fails to multiply on vegetable substrata, like potato, and grows feebly in most nutritive media. In these respects it differs very markedly from the hog cholera germ, which manifests a very decided resistance to the destructive agencies in water and soil.

It seems probable that infectious matter from swine plague is more directly conveyed from one animal to another than is the case with hog cholera virus. Direct contact of the sick with the healthy must be considered as one of the principal means of infection. The mucus from the lungs contains the disease germs in abundance, and a forcible expiration by which particles of water, etc., are ejected from the nostrils to some distance may easily communicate the disease to another. The soil at the same time becomes infected from intestinal discharges; as with hog cholera, and it is therefore necessary to separate the well from the sick by removing them to uninfected grounds; but the infection of the soil and pens can not live for more than two weeks, and in a month such places may be considered safe.

The same remarks apply to both diseases as regards disinfection. This need not be so thorough in swine plague if the pens or grounds are left unused for a month, and if the healthy be kept away from the sick. At any rate, disinfection should always be practiced if possible. For this purpose lime is perhaps the best and cheapest, and for suggestions as to its use the reader is referred to page 489 of this report.

There may be some difficulty in determining which disease has attacked a given herd, or whether both are not actually present. Very severe lung disease is now the only sign that is of any positive value in the detection of swine plague, unless it be bacteriological testimony, which is the safest, but not at hand under most circumstances. Where any doubt exists the disease should be treated as hog cholera, and all the rules for disinfection and isolation which have been suggested in this and the preceding report for that disease should be followed out. In the disinfection lime should take the place of the mercuric chloride recommended in the report for 1886.

Whether this disease can be prevented by inoculation requires more evidence than has been obtained thus far, and experiments to test this matter are now going on.

UNITED STATES NEAT-CATTLE QUARANTINE.

The superintendents of the various neat-cattle quarantine stations report the names of the importers, and the number and breed of each lot of animals imported during the year 1887, as follows:

GARFIELD STATION, N. J. (NEAR NEW YORK).

DR. W. HERBERT LOWE, SUPERINTENDENT.

Date of arrival.	Name and post-office address of importer.	Port of shipment.	Name of breed.	No. of animals.
1887.				
Jan. 25	Overton Lea, Nashville, Tenn	London	Sussex	26
May 7	John Dick, Quincy, Ill	Antwerp	Simmenthal	6
May 24	G. F. Taber, Patterson, N. Y	Hull, England	Red Polled	8
May 26	L. F. Ross, Iowa City, Iowa	London	...do	9
June 6	S. A. Converse, Cresco, Iowa	...do	...do	21
July 25	E. S. Jameson, Mount Sterling, Ky	...do	...do	18
July 25	B. B. Lord & Son, Sinclairville, N. Y	Amsterdam	Holstein Friesian	4
July 25	R. Renfrew, New York City	London	Ayrshire	1
Aug. 2	Overton Lea, Nashville, Tenn	Hull, England	Sussex	3
Aug. 4	J. A. McKnight, Brooklyn, N. Y	Saint Helena	Polled	1
Aug. 13	J. H. Offord, Topeka, Kans	London	Red Polled	30
Aug. 13	William Hanke, Iowa City, Iowa	...do	...do	25
Aug. 13	J. McLain Smith, Dayton, Ohio	...do	...do	5
Sept. 8	Charles C. Burns, Springfield, Mass	Havre, France	French	3
Oct. 26	E. N. Howell, New York City	London	Guernsey	6
Dec. 10	Benjamin T. Cable, Rock Island, Ill	Liverpool	Black Aberdeen	25

LITTLETON STATION, MASS. (NEAR BOSTON).

DR. A. H. ROSE, SUPERINTENDENT.

Date of arrival.	Name and post-office address of importer.	Port of shipment.	Name of breed.	No. of animals.
1887.				
Feb. 12	Luther Adams, Boston, Mass	Liverpool	Shorthorns	30
June 1	John A. Frye, Marlboro, Mass	London	Holsteins	70
June 22	Morris & Clark, La Moille, Ill	Glasgow	Galloways	100
Oct. 17	John H. Bass, Fort Wayne, Ind	Liverpool	...do	20
Oct. 22	H. W. Keys, Newbury, Vt	London	Holsteins	29
Nov. 16	Hon. E. Burnett, Boston, Mass	Liverpool	Jersey & Guernsey.	66
Dec. 22	Luther Adams, Boston, Mass	London	Shorthorns	77

PATAPSCO STATION, MD. (NEAR BALTIMORE).

DR. F. L. KILBORNE, INSPECTOR.

Date of arrival.	Name and post-office address of importer.	Port of shipment.	Name of breed.	No. of animals.
1887.				
Feb. 25.	H. Vaughn, California	Liverpool	Herefords	43

Table showing the whole number of cattle received at the various stations from January 1, 1887, to January 1, 1888.

Garfield Station	191
Littleton Station	392
Patapsco	43
Total	626

Table showing the number of cattle received at the various stations for each month in the year.

Month.	Garfield.	Littleton.	Patapsco.	Total.
January	26			26
February		30	43	73
May	23			23
June	21	170		191
July	23			23
August	64			64
September	3			3
October	6	49		55
November		66		66
December	25	77		102
Total	191	392	43	626

Table showing the different breeds of cattle and the number of each imported during the year.

Breed.	No.	Breed.	No.
Shorthorns	107	French	3
Holsteins	99	Black Aberdeen	25
Guernseys	6	Sussex	29
Jerseys and Guernseys	66	Simmenthal	6
Galloways	120	Red Polled	116
Holstein-Friesians	4	Herefords	43
Ayrshire	1		
Polled	1	Total	626

DESCRIPTION OF PLATES.

PLATE I $\times\frac{3}{4}$.—Swine plague. Right lung of pig No. 407 (see text), showing the lateral aspect. The diseased portion is sharply demarcated from the normal portion and concealed in part by a pleural exudate of a spongy texture.

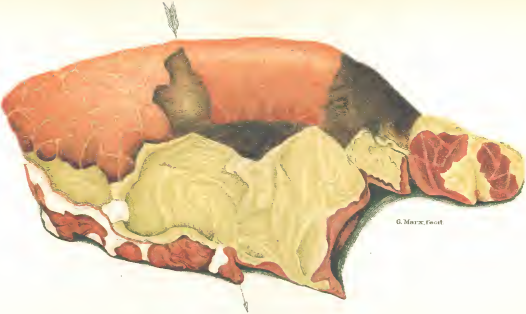
PLATE II $\times\frac{3}{4}$.—The same lung, as seen from the ventral aspect. The localization of the disease is well brought out. On the right a portion of the diaphragm is firmly adherent.

PLATE III, FIG. 1.—Section through lung of pig 407, as indicated by the arrow on Plate I. The thickened pleura with portion, of the lung tissue converted into caseous masses on the left, caseation beginning above.

FIG. 2.—Portion of lung tissue from pig No. 408, showing the grayish-yellow mottling of the surface; frequently observed in this disease, due to the cellular exudate in the ultimate bronchi and alveoli (broncho-pneumonia).

PLATE IV, FIG. 1.—Section through the lung of pig No. 396, showing cheesy masses embedded in the lung tissue; frequently observed in advanced stages of the disease.

FIG. 2.—Portion of the large intestine of the same animal covered with circumscribed masses of exudate ; frequently observed in swine plague.



SWINE PLAGUE. (Right Lung + $\frac{2}{3}$)

A.Hoen & Co. Lithocaustic Baltimore

Plate I.

G. Marx fecit

SWINE PLAGUE. (Right Lung + $\frac{2}{3}$)

A. Hoen & Co. Lithocaustic Baltimore

Plate II.

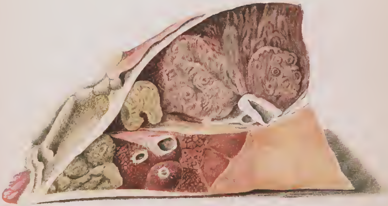


Fig. 1

Fig. 2

SWINE PLAGUE.

Plate IV.

Fig. 1.

Fig. 2.

G. Marx, fecit.

A. Hoen & Co. Lithocaustic Baltimore.

SWINE PLAGUE.

REPORT OF THE STATISTICIAN.

SIR: I have the honor to submit my nineteenth report as Statistician of this Department. Twenty-four annual reports of the Statistician have been made—those of 1863 and 1864 by Lewis Bollman, and those of 1878, 1879 and 1880 by Charles Worthington; the remainder by the present Statistician. The volume 1881–'82 comprised the work of two years.

During these twenty-four years a remarkable progress has been made in statistics, and especially in agricultural statistics. It has been an era of organization, of the creation of machinery for recording and handling data in the interest of industrial and commercial development. It has been a period of scientific discovery, of experiment in rural economy, of record of agricultural practice and the results of rural production.

The statistics of this country do not now suffice to meet the wants of legislators and business men. They want the statistics of the world. There are few products, edible or textile, which enter into consumption to any appreciable extent which are not grown or possible of growth within the national domain, and in many a surplus is produced which may enter into competition with similar products of other continents; hence the knowledge of foreign crop results, deficiencies in supply, and current prices, is eagerly sought by farmers, commercial men, and statesmen.

This pursuit of current statistical information has become so eager that data attainable and unattainable, existent and non-existent, are alike required, in season and out of season, of a character possible and impossible. Such demands, often unreasonable and annoying, attest, nevertheless, the growing importance of statistics.

That portion of our work which relates to crop reporting has become so influential in the marts of trade, so much relied upon as indications of production and the tendency of prices, that the utmost skill and care are required in the presentation of results of our investigations, that misunderstandings may be prevented and inaccurate views of the crop situation avoided. Unfortunately no statement can be so just, no language so plain, that satisfaction will always be given alike to all warring elements of the exchange. Unfortunately for the morals of trade, there is also deliberate misinterpretation of returns after their issue, and not unfrequently deliberate manufacture of pretended official reports prior to their receipt. This is unavoidable, at least by the Statistician, and must be endured as results of one of the weaknesses of human nature.

There is frequent criticism of the methods and machinery of crop reporting, generally by individuals who are either ignorant of the organization and its workings, or hostile to results that do not favor their present speculative purposes. Improvement is desirable, and practical suggestions promising betterment, however slight, would

be heartily welcomed; but when changes are proposed, crude and impracticable, or plausible but impotent, all looking backward or downward, there is little encouragement for the consideration of new schemes for statistical collection.

CURRENT CROP STATISTICS.

In a study of agricultural production, its changes and progress, the factor of meteorology is not to be disregarded. Its influence in the present season has excited much attention, as it has caused great irregularity in rate of yield and changes in market prices. In considering the productiveness of the year, the records of the Signal Service are called into requisition at the outset, and arranged to facilitate a clear general view of the temperature and rain-fall of the season.

The temperature of the growing season was slightly below the average in the Eastern and Middle States, and a deficiency somewhat greater was recorded for the Southern Atlantic States and for the Rio Grande Valley. It was quite normal in the Eastern Gulf States for the season, slightly higher in May, and a little lower in June. In the Valley of the Ohio, of the Missouri, the Lake regions, and the Northwest, temperature was decidedly high, the increase commencing in April in Missouri Valley and the Northwest, and falling below normal in August. In the Ohio Valley and Lake region no increase was recorded until May; high temperature continuing through August in the valley, and declining earlier in the Lake country. At least one-fourth of the usual difference in temperature of the season between the Ohio Valley and the Gulf region was eliminated, and from May to July, inclusive, the difference was much less, being wholly obliterated in July.

Rain-fall was above the average in the Middle Atlantic region, deficient in the Eastern and in the Southern Atlantic States, less than normal by about 2 inches in the Eastern Gulf States, the deficiency becoming larger farther West, and throughout the interior valleys northward to the Lakes.

The following summary shows the unusual deficiency in these regions, and at the same time the normal and seasonable supply of the extreme Northwest, thus explaining the comparative productiveness of Dakota the present season:

Districts.	Rain-fall.		Departure of 1887 from the normal.
	For a series of years.	For 1887.	
	Inches.	*Inches.*	*Inches.*
New England	23.83	20.11	—3.72
Middle Atlantic	22.36	23.34	+ .98
South Atlantic	31.19	28.54	—2.65
Eastern Gulf	29.96	28.05	—1.91
Western Gulf	23.94	18.25	—5.69
Ohio Valley and Tennessee	23.71	19.40	—4.31
Lower Lake region	19.24	13.95	—5.29
Upper Lake region	19.95	13.51	—6.44
Extreme Northwest	14.57	14.07	—.50
Upper Mississippi Valley	23.51	15.37	—8.14
Missouri Valley	22.38	19.31	—3.07
North Pacific coast	13.11	14.77	+1.66
Middle Pacific coast	4.26	2.68	—1.58

Average temperature by districts.

Districts.	April.		May.		June.		July.		August.		September.	
	For several years.	1887.	For several years.	1887.	For several years.	1887.	For several years.	1887.	For several years.	1887.	For several years.	1887.
	°	°	°	°	°	°	°	°	°	°	°	°
New England	43.5	41.4	54.3	57.0	63.3	62.6	68.8	70.9	67.3	66.1	62.1	58.8
Middle Atlantic	51.0	49.5	62.2	65.4	71.0	70.6	75.5	78.7	73.5	72.5	68.8	64.4
South Atlantic	62.8	61.8	71.3	71.9	77.5	76.4	80.7	80.7	78.7	78.3	75.1	72.1
Florida Peninsula	71.7	70.4	77.0	75.4	82.3	78.5	84.0	82.6	83.0	83.0	81.5	79.5
Eastern Gulf	66.0	66.1	73.0	74.5	79.2	78.3	80.8	80.0	79.6	79.6	76.0	75.9
Western Gulf	66.0	67.1	73.1	73.6	79.5	78.3	81.8	82.2	80.6	80.9	76.4	76.8
Rio Grande Valley	75.0	73.9	79.0	78.1	83.5	80.1	84.4	82.8	84.4	83.6	80.1	79.1
Ohio Valley and Tennessee	56.0	56.5	65.9	69.8	73.5	74.2	76.3	80.3	74.8	75.6	69.4	69.2
Lower Lake region	44.2	43.4	57.1	61.8	65.8	67.2	70.3	75.6	69.2	68.4	64.1	60.1
Upper Lake region	39.5	39.2	52.2	56.8	61.4	63.2	66.9	70.9	65.4	64.6	59.5	57.3
Extreme Northwest	38.8	40.6	53.6	58.4	63.6	66.7	66.8	67.9	64.8	62.8	53.8	56.3
Upper Mississippi Valley	51.3	53.1	62.2	67.1	70.5	72.9	74.9	78.4	73.0	72.8	65.3	64.4
Missouri Valley	47.6	51.4	59.8	64.1	68.5	71.1	73.7	75.3	71.7	69.9	62.6	63.7
Northern slope	41.8	44.0	53.0	55.8	62.5	63.0	68.4	68.0	66.4	64.0	55.4	57.8
Middle slope	51.0	53.5	60.4	64.1	70.4	72.4	75.7	76.1	73.0	73.4	65.7	66.8
Southern slope	58.7	59.5	69.7	71.0	76.6	76.5	79.3	81.1	77.0	78.7	70.0	72.1
Southern plateau	55.9	56.5	64.5	65.3	72.9	74.9	77.0	76.9	74.5	75.6	68.1	70.4
Middle plateau	44.5	44.4	56.0	58.5	65.6	65.6	73.6	73.8	72.0	71.3	61.5	62.9
Northern plateau	49.4	49.3	56.4	59.3	64.7	62.3	70.0	73.1	68.7	70.3	57.8	60.4
North Pacific coast	48.4	47.3	54.4	53.9	58.4	56.5	61.3	59.5	60.7	59.5	56.5	56.2
Middle Pacific coast	56.0	56.4	60.0	59.4	67.0	68.1	71.0	69.8	69.7	68.9	66.4	69.1
South Pacific coast	58.0	59.1	62.0	62.6	65.0	65.4	68.0	68.0	69.6	67.4	67.5	67.0

Average rain-fall by districts.

	Ins.	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*
New England	3.54	3.48	3.66	1.40	3.40	4.21	5.90	4.94	4.10	3.84	3.23	2.24
Middle Atlantic	2.98	2.85	3.19	2.21	3.78	4.26	4.27	5.39	4.41	5.58	3.73	3.05
South Atlantic	4.06	2.86	3.79	3.86	5.21	6.22	5.94	6.11	6.72	7.71	5.47	1.78
Florida Peninsula	2.79	3.53	2.88	3.38	6.60	7.66	6.64	7.46	7.12	3.80	5.75	4.20
Eastern Gulf	5.72	1.46	4.42	3.15	5.24	7.24	5.02	7.32	5.55	4.52	4.01	4.36
Western Gulf	4.66	.76	4.72	5.32	3.47	3.59	3.37	2.19	3.07	3.91	4.65	2.48
Rio Grande Valley	.78	.16	3.56	4.02	2.28	10.94	1.96	.16	4.07	1.55	5.84	10.27
Ohio Valley and Tennessee	4.36	4.14	3.93	3.83	4.56	2.53	4.23	3.43	3.69	2.75	2.94	2.72
Lower Lake region	2.38	1.85	3.23	2.11	3.69	3.23	3.62	1.56	3.19	2.45	3.13	2.75
Upper Lake region	2.27	1.69	3.34	2.13	4.07	1.87	3.29	3.24	3.30	1.89	3.68	2.69
Extreme Northwest	1.86	1.56	2.69	2.25	3.09	3.03	3.10	4.23	2.49	2.16	1.34	.84
Upper Mississippi Valley	3.04	2.36	4.15	2.20	5.28	2.07	3.90	2.21	3.35	2.39	3.79	4.14
Missouri Valley	2.93	2.31	4.30	1.95	4.41	3.87	4.02	3.71	3.25	4.51	3.47	2.96
Northern slope	1.79	2.54	1.88	1.65	2.50	3.33	1.77	2.01	1.39	2.99	1.02	2.12
Middle slope	2.32	2.82	3.98	4.10	3.41	2.97	3.25	1.54	2.42	2.75	2.02	2.12
Southern slope	1.33	1.19	1.87	2.66	2.82	2.66	2.76	2.99	3.69	3.40	3.08	4.78
Southern plateau	.35	.58	.29	.46	.43	.46	1.80	2.67	2.41	2.53	1.14	2.58
Middle plateau	1.76	1.48	1.01	.59	.96	.41	.51	.79	1.25	.98	.58	.53
Northern plateau	1.59	1.92	1.31	.91	1.54	1.43	.43	.43	.15	.55	.65	.59
North Pacific coast	3.15	4.88	2.50	5.04	1.70	1.04	1.21	.53	1.10	.43	3.45	2.85
Middle Pacific coast	2.94	2.42	.62	.03	.31	.11	.01	Trace	.01	Trace	.37	.12
South Pacific coast	1.54	2.25	.43	.34	.10	.06	.02	.04	.10	Trace	.10	.09

A comparison of temperature and rain-fall, by months, with the average records of a series of years, in a table in which the deviation from the normal is expressed by plus and minus signs, enables one to get a bird's-eye view of the relative heat and moisture of the season. It shows at a glance the increment of heat in connection with the diminution of moisture throughout the great and fertile central districts, the center and sum of the largest part of the production of the country. The lack of moisture is especially noticeable. continuing after the subsidence of excessive heat, and remaining in all the principal districts of production in September, except

in the Eastern Gulf States and the Upper Mississippi district. The statement is as follows:

Districts.	April.		May.		June.		July.		August.		September.	
	Temperature.	Rain-fall.	Temperature.	Rain-fall.	Temperature.	Rain-fall.	Temperature.	Rain-fall.	Temperature.	Rain-fall.	Temperature.	Rain-fall.
	°	Ins.	°	Ins.	°	Ins.	°	Ins.	°	Ins.	°	Ins.
New England	−2.1	− .06	+2.7	−2.26	− .7	+ .81	+2.1	− .96	−1.2	− .26	−3.3	− .99
Middle Atlantic	−1.5	− .13	+3.2	− .98	− .4	+ .48	+3.2	+1.12	−1.0	+1.17	−4.4	− .68
South Atlantic	−1.0	−2.20	+ .6	+ .07	−1.1	+1.01	(*)	+ .17	− .4	+ .99	−3.0	−3.69
Eastern Gulf	+ .	−4.26	+1.5	−1.27	− .9	+2.00	− .8	+2.30	(*)	−1.03	− .1	+ .35
Western Gulf	+1.1	−3.90	+ .5	+ .60	−1.2	+ .12	+ .4	−1.18	+ .3	+ .84	+ .4	−2.17
Ohio Valley and Tennessee	+ .5	− .22	+3.9	− .10	+ .7	−2.03	+4.0	− .80	+ .8	− .84	− .2	− .22
Lower Lake region	− .8	− .53	+4.7	−1.12	+1.4	− .46	+4.3	−2.06	− .8	− .74	−4.0	− .38
Upper Lake region	− .3	− .58	+4.6	−1.21	+1.8	−2.20	+4.0	− .05	− .8	−1.41	−2.2	− .99
Extreme Northwest	+1.8	− .30	+4.8	− .44	+3.1	− .06	+1.1	+1.13	−2.0	− .33	+2.5	− .50
Upper Mississippi Valley	+1.8	− .68	+4.9	−1.95	+2.4	−3.21	+3.5	−1.69	− .2	− .96	− .9	+ .35
Missouri Valley	+3.8	− .62	+4.3	−2.35	+2.6	− .54	+1.6	− .31	−1.8	+1.26	+1.1	− .51
North Pacific coast	−1.1	+1.73	− .5	+2.54	−1.9	− .66	−1.8	− .68	−1.2	− .67	− .3	− .60
Middle Pacific coast	+ .4	− .52	− .6	− .59	+1.1	− .20	−1.2	− .01	− .8	− .01	−2.7	− .25

* Normal.

The records of the autumn months show that the temperature of October was slightly below normal and that of November a little above.

The precipitation of October was generally below the normal, except in Texas, Kansas, Colorado, and the extreme southeastern States. It was also less than usual in November, the greatest deficiencies occurring in the Gulf States, eastern Tennessee, and western North Carolina. A deficiency of about 1 inch was reported in the valleys of the Ohio and Mississippi. At the close of the month about 3 inches of snow remained on the ground in the northern portion of the Lake region, in western New York, northeastern Ohio, and from 1 to 2 inches in the Ohio Valley, northern New England, and from Kansas northward to Minnesota and Dakota. Slight excess of rainfall occurred in southern Missouri, northern Louisiana, upper Michigan, New Hampshire, Vermont, Arizona, and in the extreme eastern portion of Texas.

The year 1887 has not been one of quite average production in the United States. The cause is that most frequently operative in this country—drought. The winter crops, or those maturing before August, have mainly escaped injury from this cause. Thus, cotton, corn, and potatoes are most liable to injury, and they are the crops which have been reduced heavily. Even corn has partially escaped, in some of the Southern States, by reason of maturing before the most serious effects of continual dryness were felt.

CROPS OF THE YEAR.

There was planted an enlarged area of corn, amounting to about 78,000,000 acres. The planting season was favorable for seeding, germination, and early growth. There were seasonable rains in June, very abundant in certain Atlantic districts. There were exceptions

in several Western States, an absence of rain-fall being indicated in the very heart of the corn-growing belt. As the season advanced the drought became alarming. It was everywhere a matter of surprise, however, that corn maintained so well its condition without rain. In many a field that was planted early, after thorough preparation with suitable subsequent cultivation, growth continued and a fine crop was matured, less than a good season would have made, but a yield even greater than the average of ordinary cultivation.

The drought was more limited in area than in 1881. It was worst in the lower elevations of the great interior valleys. It was severe in Kentucky, Ohio, Indiana, Illinois, part of Iowa, Missouri, and Kansas. Southern Wisconsin and Michigan were not exempt, and southeastern Minnesota was touched slightly. Other parts of Minnesota and Dakota, and Nebraska in less degree, had seasonable rainfall and high condition. In the Southwest, also, the drought was protracted, yet corn matured before its most destructive effects could be produced.

On the Atlantic coast there was generally a good supply of moisture, at certain points in excess, and in small districts it was so unequally distributed as to cause injury, attributed by some to drought and by others to excess of moisture followed by high temperature.

The result of these changing conditions was very disappointing, raising the hopes of cultivators, then suddenly depressing them, perhaps unduly, by the suddenness and severity of the decline. This will be best shown, as to corn and cotton especially, in the following general monthly averages of condition of several crops:

Months.	Corn.	Winter wheat.	Spring wheat.	Oats.	Barley.	Cotton.	Potatoes.	Tobacco.
June	....	84.9	87.3	91.0	87.0	96.9	....	....
July	97.7	83.5	79.3	85.9	82.8	96.9	93.2	84.2
August	80.5	....	78.8	85.6	86.2	93.3	80.8	73.1
September	72.3	....	....	83.4	83.0	82.8	67.3	70.8
October	72.8	....	....	....	....	76.5	61.5	73.8

The result of the year's harvest, though slightly deficient, is an ample supply for all wants, with increased value of corn, potatoes, and hay due to diminished production, and a very slight advance in oats, while other grain remains within a point or two of the prices current a year ago.

The acreage of corn is diminished by eliminating over 5,000,000 acres of worthless or abandoned area, and on this reduced area a yield of only 20.1 bushels per acre is recorded. Counting the original area, as is usually done, without allowances for areas of absolute failure, the average yield would be 18.7 bushels per acre, about the same as in 1881. As the Atlantic coast States make better returns than in 1881, it follows that in extent and intensity the drought of this season is scarcely equaled by any previous infliction. This can only be taken as a general average, some localities having better and others worse yields than in 1881.

It has been shown, as often before, that the best cultivation is attended with the least loss in dry seasons; and also that the areas that are tile-drained have produced larger yields than those undrained, from a better aeration of the soil and superior facilities for obtaining moisture from the subsoil.

The estimated corn area harvested for grain is 72,392,720 acres; product, 1,456,161,000 bushels; value, $646,106,770.

The preliminary report of winter wheat area indicated a decrease of about 2 per cent. The later estimates made the decline still less, scarcely more than 1 per cent. The spring wheat area showed a much larger increase, making the total area in wheat 37,641,783 against 36,806,184, or an increase of over 2 per cent. on the entire acreage.

The condition of winter wheat in June was fairly good upon a large portion of the breadth, and suffered little reduction up to the time of harvest. The injury from the Hessian fly was slight, though its presence was indicated locally in Pennsylvania, Maryland, Virginia, West Virginia, Kentucky, Ohio, Michigan, Indiana, and Illinois. In a few small districts serious losses from these pests are reported.

In June the depredations of chinch-bugs began to be serious in the winter wheat of Maryland and Virginia, and in the spring wheat of southeastern Minnesota. In some districts in northern Illinois spring wheat was nearly destroyed by them. The losses of wheat have this year been due to insects much more than to drought.

The crop as harvested, of both winter and spring wheat, makes an average of slightly over 12.1 bushels per acre, which is precisely the average of eight years past. The winter wheat averages 12.1 bushels, and the spring wheat 12.2 bushels, both slightly lower than in 1886.

The relative yields of the principal spring-wheat districts compare with last year as follows:

Years.	Wisconsin.	Minnesota.	Dakota.	Iowa.	Nebraska.
1886	11.5	14.0	11.5	12.2	11.0
1887	10.3	11.6	14.3	10.0	10.1

The most manifest difference is the reversal of conditions in Minnesota and Dakota, caused by the destructive presence of chinch-bugs and drought in southeastern Minnesota this year, and the comparative exemption from both evils in Dakota. The comparison of averages of condition of these States the 1st of August, 1886 and 1887, just before the harvest, shows an expectation which foreshadows substantially the result as given in the above yields:

Years.	Wisconsin.	Minnesota.	Dakota.	Iowa.	Nebraska.
1886	73	80	62	97	82
1887	73	74	88	72	77

The September report of condition when harvested, in 1886, raised 80 to 87 in Minnesota and increased 73 to 78 for Wisconsin, showing a better result than had been expected in those States. The whole course of the season's conditions has this year been favorable to Dakota wheat, and comparatively unfavorable to that of the remainder of the spring-wheat district, a part of Minnesota especially.

The yield of the remaining cereals has been nearly an average the present year, as in the case of wheat.

The area of cotton was slightly increased, equivalent to about 1 per cent. Condition was high in June and July until the effects of drought began to be manifest. The crop was kept in unusually clean cultivation with a stand better than the average. On the 1st of August a decline of four points was apparent. In the eastern portion of the belt there had generally been an excess of moisture, in some places damaging floods, and the "weed" was large and sappy, causing rust and fall of forms under the high temperature following. In Texas drought began to be injurious. Yet up to this date the average of condition was comparatively high. A heavy decline followed. The following comparison of condition will show the course of each season:

Years.	June.	July.	August.	September.	October.
1886	88.7	86.1	81.3	82.1	79.3
1887	96.9	96.9	93.3	82.8	76.5

In 1886 the decline was less than 10 points; in 1887 it was more than 20, almost wholly in August and September. The State estimates of yield per acre made 33.8 hundredths of a bale, against 36 hundredths in 1886. The estimates of yield per acre in November averaged 164 pounds, against 168 the previous year. On the basis of these results a crop of 6,306,150 bales was indicated in the November report. This was a material decline from earlier expectation, when condition stood nearly at the standard of perfect healthfulness and good growth; yet it was in accordance with the returns of correspondents at that stage of the harvest, two months before its close. It was intimated in November that the early growth and stamina of the plant might carry the yield beyond the logical results of the depressed condition reported by our correspondents. This proved to be the case; but the largest factor of increased product was the late occurrence of killing frost and the fine season for maturing and picking, which brought the aggregate nearly up to the total of the largest crop ever produced—that of 1882, which was nearly 7,000,000 bales.

The season has not been favorable for a large crop of hay. It was considerably reduced in the region affected by the drought, causing a heavy advance in farm prices, and increasing about $2 per ton the general average of the country.

The season has been peculiarly unfavorable for the Northern potato crop. With an area larger than that of the previous crops, the yield is the smallest for many years. The yield averaged slightly above 56 bushels per acre, indicating a crop of about 134,000,000 bushels. While condition was lowest in the West throughout the growing season, the loss from rotting near the time of harvest was greater in the East, Maine especially.

There was a fair crop of sweet potatoes, which is a very important edible crop of the South, possibly aggregating 40,000,000 bushels, which is an increase of nearly 25 per cent. since 1880. It is of course limited in area, while the round potato, *Solanum tuberosum*, is a product of every State and Territory, either as a winter or summer crop.

It has been a poor year for orchard fruits, which have been relatively high in price during the season. In parts of Connecticut a

good crop of apples was secured, and a moderate crop in many counties of New England, with a partial crop in New York.

CORN.

This crop is distinctively American. Though grown in southern Europe and in South America, the product of the United States comprises nearly three-fourths of the maize of the world. Its importance in the rural economy of this country is shown by the fact that its present area is 51 per cent. of the breadth of all cereals, and its last product, less by one-fifth than an average crop, is 55 per cent. of the quantity of all cereals.

The supply to each unit of population is far greater than the aggregate supply of all cereals in all other countries. It was, in 1849, 25.5 bushels; in 1859, 26.7 bushels; in 1869, 19.7 bushels; in 1879, 35 bushels. Since 1880 there has been only one season, 1885, of average yield. The decline is due to meteorological causes rather than to declining fertility.

While it is not exported largely, as grain or meal, there is another form of exportation, as pork products, and in much smaller measure as beef and spirits, which helps prices. Still its price is very little dependent on foreign markets, so large and varied are its uses at home. It has happened that the high value set by home demand has almost entirely shut off foreign orders for grain and greatly reduced the foreign trade in secondary products of maize.

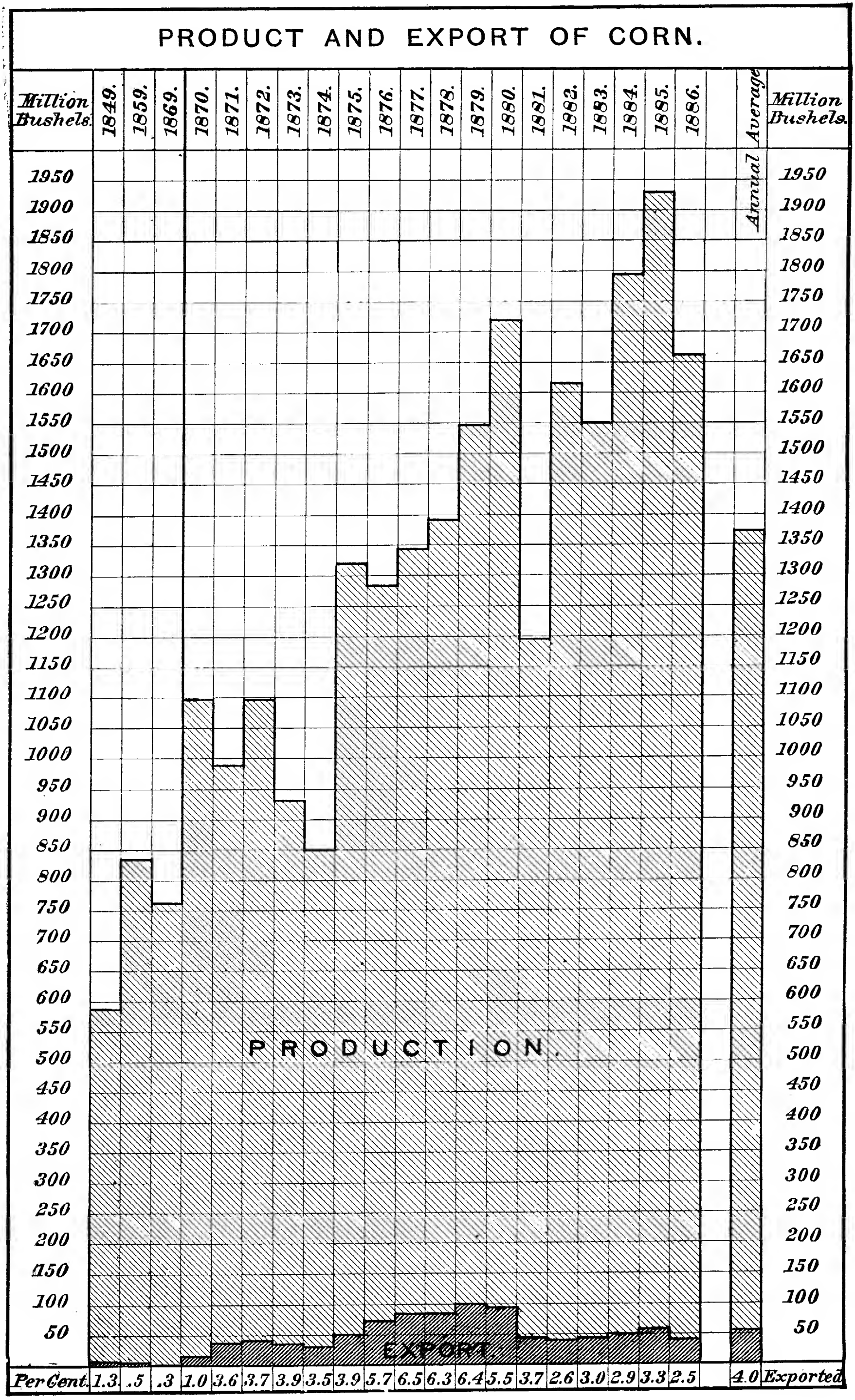
The fluctuations in prices have been great, from 63.6 cents in 1881 to 32.8 in 1885, due to the relative size of the crop. The value per acre for the decade 1870 to 1879 was $11.54 per acre; for eight years past $9.82. The former was slightly increased by the foreign demand for meat products prior to 1880, and the latter is slightly depressed in sympathy with the tendency of an era of low prices.

Comparing the statistics of eight years with those of the preceding decade, while the acreage has increased very nearly with the increment of population, the product has not, averaging 1,616,718,567, a quantity less than that of the good crop year 1880.

The following table exhibits recent maize statistics, and presents a comparison with the previous decade:

Years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value per acre.
	Bushels.	*Acres.*		*Cents.*	*Bushels.*	
1880	1,717,434,543	62,317,842	$679,714,499	39.6	27.6	$10.91
1881	1,194,916,000	64,262,025	759,482,170	63.6	18.6	11.82
1882	1,617,025,100	65,659,546	783,867,175	48.4	24.6	11.94
1883	1,551,066,895	68,301,889	658,051,485	42.4	22.7	9.63
1884	1,795,528,000	69,683,780	640,735,560	35.7	25.8	9.19
1885	1,936,176,000	73,130,150	635,674,630	32.8	26.5	8.69
1886	1,665,441,000	75,694,208	610,311,000	36.6	22.0	8.06
1887	1,456,161,000	72,392,720	646,106,770	44.4	20.1	8.93
Total	12,933,748,538	551,442,160	5,413,943,289	....	....	....
Annual average	1,616,718,567	68,930,270	676,742,911	41.9	23.5	9.82
Annual average for preceding ten years.	1,184,486,954	43,741,331	504,571,048	42.6	27.1	11.54

The home consumption of the ten-year period averaged 25 bushels per capita; of the recent period of eight years, about 27.5 bushels, a 10 per cent. increase. Therefore, while the average yield per acre


PRODUCT AND EXPORT OF CORN.
Million Bushels.
1849. 1859. 1869. 1870. 1871. 1872. 1873. 1874. 1875. 1876. 1877. 1878. 1879. 1880. 1881. 1882. 1883. 1884. 1885. 1886.
Annual Average
1950 1900 1850 1800 1750 1700 1650 1600 1550 1500 1450 1400 1350 1300 1250 1200 1150 1100 1050 1000 950 900 850 800 750 700 650 600 550 500 450 400 350 300 250 200 150 100 50
PRODUCTION.
EXPORT.
Per Cent. 1.3 .5 .3 1.0 3.6 3.7 3.9 3.5 3.9 5.7 6.5 6.3 6.4 5.5 3.7 2.6 3.0 2.9 3.3 2.5 4.0 Exported

was only 23.5 bushels against 27.1 bushels, the extension of area more than supplied the deficiency, keeping the price from advancing, the average being 41.9 cents per bushel against 42.6 cents. It should not be regarded as an abnormal or unnecessary extension, as a moderate price is a necessity for a profitable production of milk and meat and other products into which maize enters as an element. The value per acre averages $1.72 less than that of the decennial period between 1870 and 1880. He who grows corn to sell and not to convert into various extended products of maize is at a comparative disadvantage as prices rule at present.

Diagram A shows the increase of production and makes distinction between that consumed at home and that sent abroad as grain and meal, according to the following statement:

Production and export of corn.

Years.	Production.	Exports.	Production.	Years.	Production.	Exports.	Production.
	Bushels.	*Bushels.*	*Per cent.*		*Bushels.*	*Bushels.*	*Per cent.*
1849*	592,071,104	7,632,860	1.3	1878	1,388,218,750	87,884,892	6.3
1859*	838,792,742	4,248,991	.5	1879	1,754,591,676	99,572,329	5.7
1869*	760,944,549	2,140,487	.3	1880	1,717,434,543	93,648,147	5.5
1870	1,094,255,000	10,673,553	1.0	1881	1,194,916,000	44,340,683	3.7
1871	991,898,000	35,727,010	3.6	1882	1,617,025,100	41,655,653	2.6
1872	1,092,719,000	40,154,374	3.7	1883	1,551,066,895	46,258,606	3.0
1873	932,274,000	35,985,834	3.9	1884	1,795,528,000	52,876,456	2.9
1874	850,148,500	30,025,036	3.5	1885	1,936,176,000	64,829,617	3.3
1875	1,321,069,000	50,910,532	3.9	1886	1,665,441,000	41,368,584	2.5
1876	1,283,827,500	72,652,611	5.7				
1877	1,342,558,000	87,192,110	6.5	Annual av'ge.	1,384,067,468	55,044,472	4.0

* Census.

The area of maize planted in 1887 was increased more than 2,000,000 acres, yet the virtual destruction of area which failed wholly to mature, and was valuable only for stover, reduced the breadth harvested to 72,392,720 acres, instead of 75,694,208 acres the previous year. The yield per acre on this reduced acreage was 20.1 bushels, instead of 22 in 1886, which was less by 4 bushels than an average crop. The area, product, and value by States are as follows:

States and Territories.	Acres.	Bushels.	Value.
Maine	32,165	1,132,000	$769,760
New Hampshire	38,578	1,323,000	912,870
Vermont	62,091	2,204,000	1,498,720
Massachusetts	59,997	2,124,000	1,486,800
Rhode Island	12,946	414,000	289,800
Connecticut	58,140	1,977,000	1,324,590
New York	709,406	23,410,000	13,343,700
New Jersey	346,866	10,406,000	5,723,300
Pennsylvania	1,394,561	44,905,000	22,452,500
Delaware	216,595	4,332,000	1,862,760
Maryland	719,073	19,415,000	8,736,750
Virginia	2,153,126	37,680,000	17,709,600
North Carolina	2,673,910	35,830,000	21,139,700
South Carolina	1,501,322	15,013,000	9,308,060
Georgia	2,915,140	32,067,000	20,202,210
Florida	454,306	4,816,000	3,419,360
Alabama	2,464,827	33,522,000	18,101,880
Mississippi	1,886,319	32,633,000	17,295,490
Louisiana	1,001,226	18,022,000	9,191,220
Texas	4,499,405	76,490,000	39,009,900
Arkansas	2,068,349	41,367,000	20,683,500
Tennessee	3,497,848	75,204,000	37,602,000
West Virginia	658,755	12,516,000	6,758,640
Kentucky	3,160,668	57,840,000	30,655,200
Ohio	2,805,961	73,797,000	35,422,560
Michigan	841,316	18,930,000	9,086,400
Indiana	3,569,994	71,400,000	32,130,000

States and Territories.	Acres.	Bushels.	Value.
Illinois	7,347,915	141,080,000	$57,842,800
Wisconsin	1,018,778	25,775,000	10,825,500
Minnesota	606,756	18,081,000	6,689,970
Iowa	7,196,148	183,502,000	64,225,700
Missouri	6,406,785	140,949,000	52,151,130
Kansas	5,242,979	76,547,000	28,322,390
Nebraska	3,865,158	93,150,000	27,945,000
California	156,752	4,703,000	2,868,830
Oregon	6,673	182,000	116,480
Nevada	863	24,000	14,880
Colorado	31,267	938,000	590,940
Arizona	3,111	59,000	38,350
Dakota	636,120	20,992,000	7,347,200
Idaho	1,989	56,000	33,600
Montana	908	25,000	15,000
New Mexico	51,056	970,000	698,400
Utah	13,197	285,000	213,750
Washington	3,375	74,000	49,580
Total	72,392,720	1,456,161,000	646,106,770

With a steady increase of area, amounting to about 21 per cent. since 1879, the product of this year is the smallest of the series, excepting only that of 1881. It is less by 9.9 per cent. than the average for the period. This average product of eight years is 36.5 per cent. larger than that of the ten years preceding.

The crop of 1887 was one of the lowest in yield ever made. Its large area made its product respectable in absolute quantity. The cause of decline was drought, which in portions of the western corn belt surpassed in intensity that of 1881 in the same districts. The damage did not extend to the Atlantic coast, as in that disastrous year, nor was it so great on the Gulf coast.

On the first of March of each year an investigation is undertaken to show the proportion already consumed or distributed. It shows that small crops are husbanded and large ones more profusely used, as to aggregate bushels, though the proportion of crop disposed of is larger in the case of the small crop. While the remainder is smaller in percentage, and still smaller in comparative quantity, in the small crop year, it is shown that the consumption has been greatly economized in such years. The following table presents these comparisons for a series of years:

March 1—	Product.	On hand March 1.	Per cent.	Consumed or distributed.
	Bushels.	*Bushels.*		*Bushels.*
1883	1,617,000,000	587,000,000	36.3	1,030,000,000
1884	1,551,000,000	512,000,000	33.0	1,039,000,000
1885	1,795,000,000	675,000,000	37.6	1,120,000,000
1886	1,936,000,000	773,000,000	39.9	1,163,000,000
1887	1,665,000,000	603,000,000	36.2	1,062,000,000
1888	1,456,000,000	508,000,000	34.9	948,000,000

The effect of the drought is seen in the amount already consumed or distributed, which falls under 1,000,000,000 bushels for the first time in six years, and is less by a 114,000,000 bushels than in the previous year, and less by 215,000,000 than in 1886, when the largest quantity ever reported was in course of distribution.

The smallest rate of consumption at this date is in the South, which requires less winter feeding and more in spring and early summer to sustain the plow animals employed in the cultivation of corn and cotton. The West, the region of winter feeding, has con-

sumed a larger proportion than in any year since 1882, or almost 70 per cent. The proportions consumed in the several sections, or groups of States, are as follows:

Sections.	1883.	1884.	1885.	1886.	1887.	1888.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
New England	70.2	66.2	62.9	61.6	63.3	65.4
Middle	62.6	68.2	63.4	59.3	61.8	65.6
Southern	56.5	58.6	58.6	54.6	58.1	55.5
Western	66.2	69.3	63.3	61.6	65.6	69.6
Pacific	74.6	70.7	60.4	68.4	70.5	78.3
Nevada, Colorado, and Territories	65.0	70.2	65.5	63.3	67.0	59.5

Considering quantities rather than proportions, the real significance of the changes in distribution are seen. The South, with a good crop, has almost 30,000,000 bushels in excess of the stock of last March on hand; while the West, where drought was so severe, has a stock less by over 127,000,000 bushels, a reduction of almost one-third, notwithstanding the stringent economy in feeding enforced by scarcity and high prices. The comparison, by sections, of the quantities on hand at the 1st of March of recent years is as follows:

Sections.	1885.		1886.		1887.		1888.	
	Bushels.	*P. ct.*	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*
New England	3,132,944	37.1	3,344,420	38.4	3,208,200	36.7	3,177,620	34.6
Middle	29,712,800	36.6	34,165,780	40.7	29,045,170	38.2	28,595,170	34.4
Southern	144,798,860	41.4	178,606,340	45.4	158,354,600	41.9	187,825,040	44.5
Western	490,021,950	36.7	549,084,080	38.4	405,409,820	34.4	278,119,160	30.4
Pacific	1,965,920	39.6	1,258,400	31.6	1,310,640	29.5	1,061,960	21.7
Nevada, Colorado, and Territories	5,578,190	34.5	6,587,470	36.7	6,016,220	33.0	9,494,560	40.5
Total	675,210,664	37.6	773,046,490	39.9	603,344,650	36.2	508,273,510	34.9

The scarcity of corn in the West appears more conspicuous by showing its relative proportion to the aggregate of the stocks on hand. Two years ago the Western remainder was 71 per cent. of the whole; now it is only 55 per cent. Two years ago the Southern remainder was 23 per cent. of the whole; now it is 37 per cent. This explains what could not be understood in the drought districts, even by intelligent men, when the crop prospects of the whole country pointed to an aggregate so much above the indications of the crops in their immediate vicinity. This explains more than three-fourths of the incredulity and criticism to which crop reports are subjected. The man who has not been out of his own township is vastly more confident and dogmatic than he who has visited several States. The latter, however, is sure to judge of forty States and Territories solely by what he has seen of the remainder.

This western division, comprising twelve States, may be appropriately reduced to seven, usually known as the corn-surplus States, which alone make any material contributions to the commercial supply. These States show a remainder only one-half of that of two years ago. A reduction from 481,713,960 to 240,559,080 is extraordinary, and would make more impression on prices than is yet apparent but for the prevailing general depression of values. Iowa appears to have the largest stock, and the largest proportion with the exception of Nebraska. In these States the reduction from last year's stock in March exceeds 100,000,000 bushels. As the commercially available maize is nearly all in these States, it is seen that the statistical situa-

tion is more favorable for high prices of corn than for several years. The statement is as follows:

States.	1885.		1886.		1887.		1888.	
	Bushels.	*P. ct.*	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*
Ohio	31,595,410	37	42,508,700	38	33,671,400	35	22,139,100	30
Indiana	37,712,520	36	50,157,720	38	43,954,150	37	19,992,000	28
Illinois	80,699,520	33	107,599,200	40	77,632,660	37	43,734,800	31
Iowa	95,988,000	38	92,148,480	38	59,654,100	30	62,390,680	34
Missouri	65,290,500	33	70,869,960	36	43,112,700	30	39,465,720	28
Kansas	70,770,000	42	60,188,200	38	40,547,840	32	18,371,280	24
Nebraska	54,945,000	45	58,241,700	45	45,635,470	43	34,465,500	37
Total	437,000,950	37.2	481,713,960	38.8	344,208,320	34.4	240,559,080	30.8

An inquiry is made to ascertain as nearly as practicable the proportions in each county intended for home consumption separated from those held for shipment beyond the county lines. This table makes a smaller quantity held as surplus than has been reported since 1882. It is scarcely 12 per cent. of the crop—170,340,420 bushels—against 288,640,900 reported last March. The usual proportion has been one-sixth to one-fifth. Not all of this surplus is shipped to commercial markets; not a little, in seasons of abundance and consequent cheapness, is shipped short distances across county lines by feeders of cattle, sheep, or swine. In the present season this source of distribution is a limited factor of the movement.

In the Western group one-fifth of the crop is usually handled commercially; this year only one-eighth. The eighth of this crop is only half as much as the fifth of the previous one. The statement by sections is as follows:

Sections.	1887.				1888.			
	Retained for county consumption.		Distribution beyond county lines.		Retained for county consumption.		Distribution beyond county lines.	
	Bushels.	*P. ct.*	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*
New England	8,645,670	99.0	87,330	1.0	9,073,980	98.9	100,020	1.1
Middle	68,652,630	90.4	7,326,370	9.6	74,758,850	90.0	8,294,150	10.0
Southern	337,425,510	89.3	40,440,490	10.7	379,216,690	89.8	42,842,310	10.2
Western	942,102,680	79.8	238,096,320	20.2	797,003,590	87.2	116,563,410	12.8
Pacific	3,923,220	88.4	516,780	11.6	3,938,940	80.6	946,060	19.4
Nevada, Colorada, and Territories	16,050,390	88.1	2,173,610	11.9	21,828,530	93.2	1,594,470	6.8
Total	1,376,800,100	82.7	288,640,900	17.3	1,285,820,580	88.3	170,340,420	11.7

Taking the entire breadth as a whole the merchantable corn was slightly above the average. It was a little less than that of the previous crop, which was not so good as the crop of 1884, though better than that of 1885, and much better than the frosted crop of 1883.

The proportion and quantity of merchantable and unmerchantable, respectively, in the past five years is as follows:

Years.	Merchantable.		Unmerchantable.	
	Bushels.	*Per. cent.*	*Bushels.*	*Per. cent.*
1883	935,926,541	60	615,140,354	40
1884	1,593,332,101	89	202,196,331	11
1885	1,583,012,860	78	353,163,140	22
1886	1,438,446,830	86	226,994,170	14
1887	1,222,166,360	84	233,994,640	16

Proportion and value per bushel and total value of merchantable and unmerchantable corn.

States and Territories.	Merchantable.			Unmerchantable.		
	Bushels.	Price per bushel.	Value.	Bushels.	Price per bushel.	Value.
		Cents.			Cents.	
Maine	950,880	80	$760,704	181,120	52	$94,182
New Hampshire	1,164,240	80	931,392	158,760	52	82,555
Vermont	1,917,480	72	1,380,586	286,520	46	131,799
Massachusetts	1,847,880	75	1,385,910	276,120	45	124,254
Rhode Island	356,040	78	277,711	57,960	48	27,821
Connecticut	1,640,910	74	1,214,273	336,090	34	114,271
New York	19,664,400	64	12,585,216	3,745,600	31	1,161,136
New Jersey	9,053,220	61	5,522,464	1,352,780	31	419,362
Pennsylvania	38,618,300	56	21,626,248	6,286,700	30	1,886,010
Delaware	3,898,800	52	2,027,376	433,200	32	138,624
Maryland	17,085,200	54	9,225,008	2,329,800	33	768,834
Virginia	32,028,000	56	17,935,680	5,652,000	32	1,808,640
North Carolina	30,455,500	62	18,882,410	5,374,500	33	1,773,585
South Carolina	13,211,440	76	10,040,694	1,801,560	35	630,546
Georgia	27,256,950	77	20,987,852	4,810,050	36	1,731,618
Florida	4,141,760	78	3,230,573	674,240	35	235,984
Alabama	29,499,360	67	19,764,571	4,022,640	34	1,367,698
Mississippi	29,369,700	56	16,447,032	3,263,300	32	1,044,256
Louisiana	16,219,800	59	9,569,682	1,802,200	35	630,770
Texas	68,076,100	57	38,803,377	8,413,900	36	3,029,004
Arkansas	35,989,290	54	19,434,217	5,377,710	35	1,882,199
Tennessee	62,419,320	53	33,082,240	12,784,680	33	4,218,944
West Virginia	10,388,280	58	6,02[illegible],202	2,127,720	34	723,425
Kentucky	41,644,800	60	24,986,880	16,195,200	35	5,668,320
Ohio	63,465,420	54	34,271,327	10,331,580	34	3,512,737
Michigan	12,683,100	55	6,975,705	6,246,900	35	2,186,415
Indiana	60,690,000	52	31,558,800	10,710,000	34	3,641,400
Illinois	119,918,000	47	56,361,460	21,162,000	32	6,771,840
Wisconsin	20,362,250	48	9,773,880	5,412,750	34	1,840,335
Minnesota	13,379,940	43	5,753,374	4,701,060	26	1,222,276
Iowa	161,481,760	39	62,977,886	22,020,240	30	6,606,072
Missouri	115,578,180	44	50,854,399	25,370,820	31	7,864,954
Kansas	46,693,670	46	21,479,088	29,853,330	32	9,553,066
Nebraska	85,698,000	35	29,994,300	7,452,000	18	1,341,360
California	4,326,760	73	3,158,535	376,240	40	150,496
Oregon	160,160	70	112,112	21,840	31	6,770
Nevada	19,200	73	14,016	4,800	30	1,440
Colorado	778,540	68	529,407	159,460	42	66,973
Arizona	46,610	80	37,288	12,390	45	5,576
Dakota	18,892,800	38	7,179,264	2,099,200	25	524,800
Idaho	44,800	67	30,016	11,200	38	4,256
Montana	20,000	66	13,200	5,000	37	1,850
New Mexico	776,000	82	636,320	194,000	46	89,240
Utah	199,500	70	139,650	85,500	42	35,910
Washington	54,020	75	40,515	19,980	45	8,991
Total	1,222,166,360	50.6	618,018,840	233,994,640	32.1	75,130,594

The value of the crop on the basis of March prices of merchantable and unmerchantable corn, separately estimated, is stated as follows:

Merchantable, at 50.6 cents per bushel	$618,018,840
Unmerchantable, at 32.1 cents	75,130,594
Total value, basis of March 1	693,149,434
Value, basis of December prices	646,106,770

The average value per bushel, on the December basis, was 44.4 cents; three months later, on separate estimates of merchantable and unmerchantable, 47.6, an increase of only 3.2 cents, a very moderate difference, as prices in years of scarcity usually advance as the supply is reduced. The December value represents quite nearly the value to the growers, as a part of the crop had already been consumed or sold at still lower prices, and that date is undoubtedly a fair one on

which to take account of values. The average farm prices (December) are the highest in twelve years, except in 1881 and 1882, this exception being due entirely to failure of 1881. The advance from last year was 7.8 cents per bushel, equivalent to 21 per cent. The following statement gives annual averages for the principal corn-growing States and for the United States for twelve years:

States.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.
	Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
Kentucky	39	32	40	37	38	70	52	42	43	35	34	53
Ohio	38	40	33	39	41	61	62	47	41	32	35	48
Michigan	52	39	38	45	46	63	59	52	40	34	38	48
Indiana	34	34	27	34	40	60	48	41	34	29	32	45
Illinois	31	29	25	31	36	58	47	40	31	28	31	41
Wisconsin	41	33	29	39	39	54	53	48	34	34	37	42
Minnesota	40	38	29	27	36	53	45	43	33	32	34	37
Iowa	25	25	16	24	26	44	38	32	23	24	30	35
Missouri	28	27	26	25	36	65	39	35	26	25	31	37
Kansas	24	21	19	27	29	58	37	26	22	24	27	37
Nebraska	27	18	16	21	25	39	33	24	18	19	20	30
Dakota	......	......	......	......	......	......	51	45	30	28	37	35
United States	37	35.8	31.8	37.5	39.6	63.6	48.4	42.4	35.7	32.8	36.6	44.4

The actual export prices are herewith given. Instead of comparing those sea-port values of exports with average farm prices, the farm prices of the States beyond the Mississippi, which furnish most of the export corn, will show more accurately the cost of shipping a long distance:

Years ended June 30—	Price.	Years ended June 30—	Price.
	Cents.		*Cents.*
1878	56.2	1883	68.4
1879	47.1	1884	61.1
1880	54.3	1885	54.0
1881	55.2	1886	49.8
1882	66.8	1887	48.0

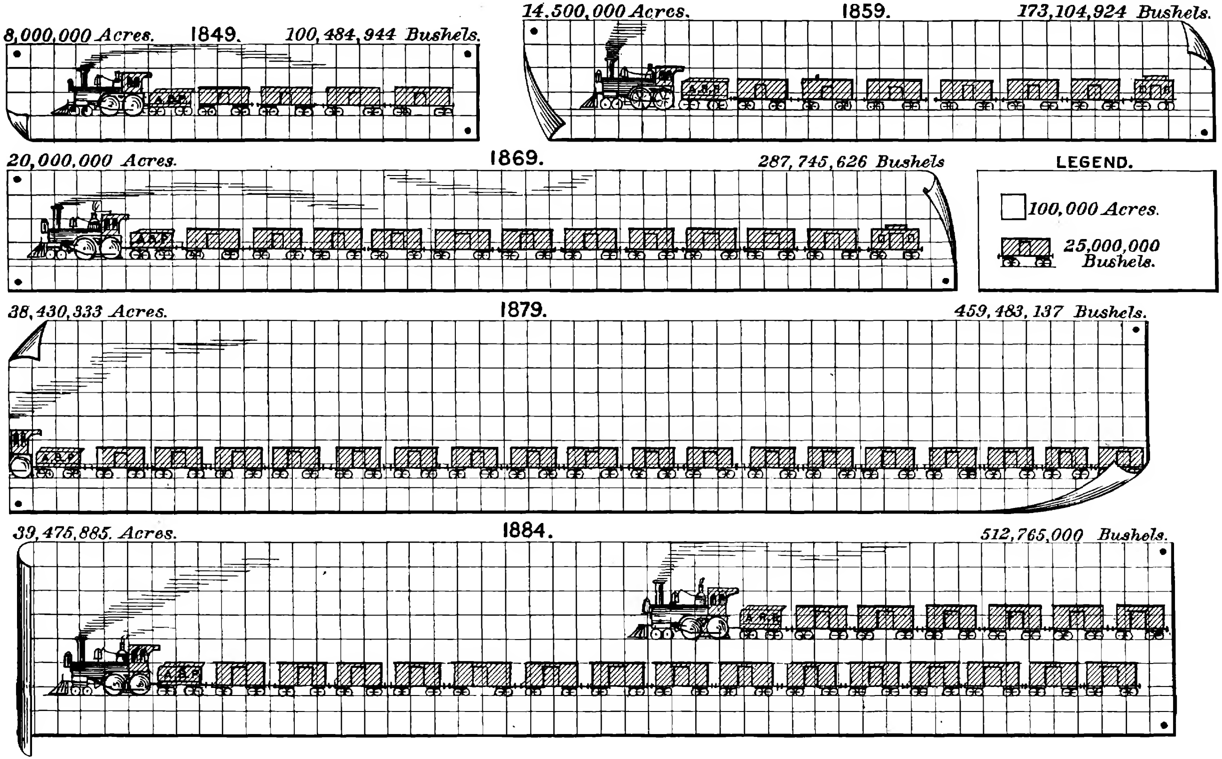
WHEAT.

Production of wheat has not only kept pace with consumption, but has recently been slightly in excess. Of course this refers to the wheat-producing nations of the world, and not merely to this country, which has increased its million acres of excess over home requirements to 10,000,000 acres at the present time, a breadth much larger than the surplus acreage of all others combined outside of Europe.

It is a significant fact in connection with the rapid increase of population, and with the decline in proportion of rural population, that the supply of forty years ago should not only be sustained but increased. In 1849 the product was 4.33 bushels for each inhabitant; in 1859, 5.5; in 1869, 7.46; in 1879, 9.16; in 1884, 9.16 per capita. For three years past the seasons have not favored a continuance of so large production.

From 1849 to 1884, a period of thirty-five years, the increase of population was 141 per cent., while the increase in production of wheat was 410 per cent.

WHEAT.—ACREAGE AND PRODUCTION.



The movement of wheat growing has been westward during this period. The increase in absolute quantities on the Atlantic coast has been very slight, while the proportion has declined from 51.4 to 12.2 per cent. Half of the crop was then produced on the Atlantic coast, the eastern slopes of the Alleghanies. In 1884 half of the crop was grown beyond the Mississippi, and only one-twentieth on the Atlantic coast. This movement is shown in the following statement:

	1849.	1859.	1869.	1879.	1884.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Atlantic coast	51,674,390	53,306,897	54,996,610	58,711,603	62,703,000
Central belt	43,522,646	94,458,609	143,360,613	229,265,180	185,136,000
Trans-Mississippi	5,288,908	25,339,418	89,388,403	171,506,354	264,926,000
Total	100,485,944	173,104,924	287,745,626	459,483,137	512,765,000

The percentages of each crop in the three subdivisions of territory are:

	1849.	1859.	1869.	1879.	1884.
Atlantic coast	51.4	30.8	19.1	12.8	12.2
Central belt	43.3	54.6	49.8	49.9	36.1
Trans-Mississippi	5.3	14.6	31.1	37.3	51.7
	100	100	100	100	100

The acreage was not officially reported in the earlier periods, but after such investigation as has been practicable, it is believed that the following statement approximates the breadth of wheat at each date:

	Acreage.	Product.
	Acres.	*Bushels.*
1849	8,000,000	100,485,944
1859	14,500,000	173, 04,924
1869	20,000,000	287,745,626
1879	35,430,333	459,483,137
1884	39,475,885	512,765,000

Diagram B presents to the eye the relative proportions of these figures, the breadth grown being indicated by the comparative surface of each field, and the quantity by comparative car capacity, typifying its movement toward consumption.

Wheat growing was stimulated greatly between 1875 and 1880 by a series of crop failures in western Europe, causing a demand which never existed before, has not existed since, and may never again, although the exigency is quite possible. Meantime the world's production has kept up, with little change or diminution, depressing prices and furnishing cheap bread to consumers and little profit to producers. And yet the inquiry is made, why are wheat prices so low? In view of these facts, the question needs no answer. It is utterly useless to pretend reduction of area, as some do, where there

is none, for prices do not depend upon prophecy of future diminution of supplies, but upon stocks in sight. It is the policy of buyers to ignore all grain not in commercial hands, even when they have no doubt of its existence, thus postponing the evil day of higher values. A false prophecy is soon exposed, bringing decay of confidence in the prophet.

The influence of overproduction on prices is seen in a comparison of the farm prices per bushel for the two periods, viz, $1.049 and $0.833, respectively, showing a reduction of 20.6 per cent. The value of an acre of wheat has declined from $13 to $10.06, a loss of 22.6 per cent. The yield has averaged three-tenths of a bushel less than for the former period, the difference being due to the extremely low yields of 1881 and 1885. The average has been 12.1 bushels per acre. Any series of five years, not including both of these two, will show a larger fraction above 12 bushels as an average. The comparison is as follows:

Years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value per acre.
	Bushels.	*Acres.*		*Cents.*	*Bushels.*	
1880	498,549,868	37,986,717	$474,201,850	95.1	13.1	$12.48
1881	383,280,090	37,709,020	456,880,427	119.3	10.2	12.12
1882	504,185,470	37,067,194	444,602,125	88.2	13.6	11.99
1883	421,086,160	36,455,593	383,649,272	91.0	11.6	10.52
1884	512,765,000	39,475,885	330,862,260	64.5	13.0	8.38
1885	357,112,000	34,189,246	275,320,390	77.1	10.4	8.05
1886	457,218,000	36,806,184	314,226,020	68.7	12.4	8.54
1887	456,329,000	37,641,783	310,612,960	68.1	12.1	8.25
Total	3,590,525,588	297,331,622	2,990,355,304	....	....	....
Annual average	448,815,699	37,166,453	373,794,413	83.3	12.1	10.06
Annual average for preceding ten years	312,152,728	25,187,414	327,407,258	104.9	12.4	13.00

The changes of the year are a slight reduction of the winter-wheat area and an increase of the spring-wheat acreage, making an increase in the breadth of wheat of over 2 per cent. The reduction of the winter variety, though small, is somewhat larger, actually, than it seems, by reason of the constant increase of population. Thus not to advance is to fall away. We need not expect an absolute reduction of the wheat area, though it will almost certainly be less relatively in the future.

The production of the year is ample for the wants of the country, and for an exportation of about 125,000,000 bushels, without trenching upon the small reserves of previous harvests. The estimates of production, as recorded in our reports, average 448,000,000 bushels, in round numbers, for seven years since 1880, not including the present year. The exportation averages nearly 136,000,000 bushels, and with estimates of seed and bread the entire distribution averages over 447,000,000 bushels. The difference is less than the losses by fire and foundering en route to market. These figures may not be absolute proof of the accuracy of the estimates, because the consumption itself is estimated. But as no one has furnished evidence to disprove the accuracy of the rate of consumption of $4\frac{2}{3}$ bushels per capita, there is no peg in existence upon which to hang a doubt of the substantial verity of the estimates. As the range of annual production is more than 150,000,000 bushels, and that of exportation as large proportion-

ally, the estimates made in advance of consumption are entirely independent of the ultimate facts of distribution, and are made entirely from the crop records of the year.

As to the per capita rate of consumption, it is almost a bushel less than that of Great Britain; and it corresponds with all data of local distribution that has been found available, especially in New England and the Middle States, which obtain a large portion of their supply from the West. Those States consume 5 bushels, and the West quite as much, while some of the Southern States require but 3 or 4. The average of 4⅗ bushels was fixed ten years ago from an exhaustive study of the local facts of distribution, and will be changed only on proof of inaccuracy, or at least a strong presumption fortified by ample facts. It should be remembered that in addition to wheat, about 3 bushels per head of maize is used for human food, besides oatmeal, rye, and buckwheat, making the fullest bread ration of any nation in the world.

If this rate is too high, then the estimates are too high; if too low, they are equally understated. That they are not too high is a reasonable conclusion from the fact that in 1879 the wheat estimate was 2 per cent. lower than the census enumeration, and in 1869 it was 6 per cent. lower, and that all estimates of area and of comparative product tend naturally to be low rather than high, notwithstanding efforts made to prevent underestimate.

The following table presents the exports and home consumption in comparison with the estimates of production, the latter made months before it is possible to know the extent of the year's contribution to the supply of the European deficiency:

Years.	Production.	For food.	For seed.	Exportation.	Total distribution.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
1880	498,549,868	242,086,655	56,563,530	186,321,514	484,971,699
1881	383,280,090	235,249,812	55,215,573	121,892,389	412,357,774
1882	504,185,470	255,500,000	52,770,312	147,811,316	456,081,628
1883	421,086,160	259,500,000	54,683,389	111,534,182	425,717,571
1884	512,765,000	265,000,000	55,266,239	132,570,367	452,836,606
1885	357,112,000	271,000,000	51,474,906	94,565,794	417,040,700
1886	457,218,000	277,000,000	51,528,658	153,804,970	482,333,628
Total	3,134,196,588	1,805,336,467	377,502,607	948,500,532	3,131,339,606
Average	447,742,370	257,905,210	53,928,944	135,500,076	447,334,229

Thus in seven years since 1879 the average of annual estimates is 447,742,320 bushels, and the distribution 447,334,229 bushels. This is marvelous closeness, especially in view of the fluctuating export, ranging from 186,321,514 to 94,565,794 bushels. Thus three-tenths of our wheat has been exported in the last seven years, and the proportion exported of the last crop (one-third) is only exceeded by the unprecedented volume and percentage of the crop of 1880, and only twice exceeded in the history of our wheat exportation.

The following table gives the estimated acreage, product, and value of the crop of 1887:

States and Territories.	Acres.	Bushels.	Value.
Maine	39,460	481,000	$505,050
New Hampshire	10,485	110,000	114,400
Vermont	21,351	320,000	307,200
Massachusetts	1,080	16,000	16,000
Connecticut	2,171	37,000	36,630
New York	666,883	10,137,000	8,312,340
New Jersey	143,083	1,459,000	1,269,330
Pennsylvania	1,421,151	13,785,000	11,165,850
Delaware	94,790	929,000	780,360
Maryland	562,836	5,797,000	4,811,510
Virginia	635,838	4,832,000	3,913,920
North Carolina	717,442	5,094,000	4,482,720
South Carolina	192,637	1,233,000	1,220,670
Georgia	382,094	2,522,000	2,395,900
Alabama	207,115	1,305,000	1,278,900
Mississippi	41,770	313,000	297,350
Texas	544,977	5,450,000	4,360,000
Arkansas	231,357	2,290,000	1,877,800
Tennessee	1,199,400	9,595,000	7,388,150
West Virginia	302,177	2,840,000	2,158,400
Kentucky	1,089,493	11,113,000	8,112,490
Ohio	2,740,087	35,895,000	26,921,250
Michigan	1,629,467	21,672,000	16,037,280
Indiana	2,802,083	37,828,000	27,236,160
Illinois	2,425,092	36,861,000	25,802,700
Wisconsin	1,268,208	13,063,000	8,360,320
Minnesota	3,129,208	36,299,000	21,416,410
Iowa	2,683,676	26,837,000	16,370,570
Missouri	1,712,603	27,744,000	17,201,280
Kansas	792,394	7,607,000	4,640,270
Nebraska	1,642,127	16,585,000	8,790,050
California	2,766,235	30,429,000	22,517,460
Oregon	920,026	16,100,000	10,948,000
Nevada	5,570	111,000	88,800
Colorado	119,709	2,514,000	1,885,500
Arizona	22,450	303,000	248,460
Dakota	3,664,737	52,406,000	27,251,120
Idaho	64,015	1,120,000	862,400
Montana	97,786	1,760,000	1,337,600
New Mexico	81,372	1,221,000	1,098,900
Utah	103,738	1,971,000	1,202,310
Washington	463,610	8,345,000	5,591,150
Total	37,641,783	456,329,000	310,612,960

On the 1st of March of each year an estimate is made of the proportion of the preceding crop still in the hands of farmers. The investigation shows a smaller proportion on hand than usual, the lowest reported except in 1882 and 1887. It is 28.9 per cent., which is less than the percentage in 1881, 1885, and 1886, and about the same as in 1883 and 1884. The crop was about the same as that of 1886, though the exportation has been less than in the previous year. The following table shows the remainders reported on hand March 1 since 1880:

Years.	Crops of previous years.	In farmers' hands March 1.	
	Bushels.	*Bushels.*	*Per cent.*
1888	456,329,000	132,000,000	28.9
1887	457,218,000	122,000,000	26.7
1886	357,112,060	107,000,000	30.1
1885	512,765,000	169,000,000	33.0
1884	421,086,160	119,000,000	28.3
1883	504,185,470	143,000,000	28.4
1882	383,280,090	98,000,000	25.6
1881	498,549,868	145,000,000	29.1

The crop was an average one in yield, and the stock remaining in farmers' hands is also near an average. The returns are full, and those of the State agent system, while not in every State identical with those from the direct correspondents of the Department, are in close agreement with them.

The crop year and the fiscal or export year beginning at the same date, July 1, the movement on the basis of actual exports and recognized consumption should be calculated from that date. It shows of uncounted wheat on the 1st of March 10,000,000 bushels, as follows:

	Bushels.	Bushels.
Visible supply July 1, 1887		34,000,000
Crop, 1887		456,000,000
		490,000,000
Consumption, July 1 to February 29, 1888	187,000,000	
Seed for winter wheat	34,000,000	
Exported July 1 to February 29, 1888	89,000,000	
Visible supply March 1, 1888	38,000,000	
In farmers' hands March 1, 1888	132,000,000	
		480,000,000
Uncounted		10,000,000

There is still an uncounted quantity, which is an element of uncertainty difficult to eliminate. It is the wheat not consumed, not in visible stock, or reported in the hands of farmers, but in country elevators, in mills, both as wheat and flour, and as flour in commercial distribution to actual consumers. This is less at the end of the crop year, when the drain of distribution, foreign and domestic, has been continuous for twelve months. It is greater in other periods of the crop year, especially after the very active distribution of the first six months.

Surplus and distribution by groups of States.

Sections.	Crop of 1887.	Stock on hand March 1, 1888.		Retained for county consumption.		Distribution beyond county lines.	
	Bushels.	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*
New England	964,000	407,220	42.2	954,360	99.0	9,640	1.0
Middle	26,310,000	9,025,380	34.3	15,872,660	60.3	10,437,340	39.7
Southern	38,431,000	9,941,230	25.9	24,787,930	64.5	13,643,070	35.5
Western	274,344,000	80,035,710	29.2	124,648,840	45.4	149,695,160	54.6
Pacific	46,529,000	13,350,120	28.7	13,045,830	28.0	33,483,170	72.0
Nevada, Colorado, and Territories	69,751,000	19,335,220	27.7	20,853,180	29.9	48,897,820	70.1
Total	456,329,000	132,094,880	28.9	200,162,800	43.9	256,166,200	56.1

The proportion reported for distribution is slightly reduced, and the aggregate is 256,166,200, instead of 263,179,110 last year.

Stock on hand and amount retained for home consumption March 1, 1888.

States and Territories.	Crop of 1887.	Stock on hand March 1, 1888.		Consumed in county where grown.		Shipped out of county where grown.	
	Bushels.	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*
Maine	481,000	173,160	36	476,190	99	4,810	1
New Hampshire	110,000	51,700	47	108,900	99	1,100	1
Vermont	320,000	166,400	52	316,800	99	3,200	1
Massachusetts	16,000	5,600	35	15,840	99	160	1
Connecticut	37,000	10,360	28	36,630	99	370	1
New York	10,137,000	3,547,950	35	6,183,570	61	3,953,430	39
New Jersey	1,459,000	466,880	32	1,065,070	73	393,930	27
Pennsylvania	13,785,000	4,824,750	35	8,271,000	60	5,514,000	40
Delaware	929,000	185,800	20	353,020	38	575,980	62

Stock on hand and amount retained for home consumption March 1, 1888—Cont'd.

States and Territories.	Crop of 1887.	Stock on hand March 1, 1888.		Consumed in county where grown.		Shipped out of county where grown.	
	Bushels.	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*
Maryland	5,797,000	1,217,370	21	1,855,040	32	3,941,960	68
Virginia	4,832,000	1,208,000	25	2,222,720	46	2,609,280	54
North Carolina	5,094,000	1,579,140	31	4,533,660	89	560,340	11
South Carolina	1,233,000	271,260	22	1,134,360	92	98,640	8
Georgia	2,522,000	630,500	25	2,269,800	90	252,200	10
Alabama	1,305,000	300,150	23	1,135,350	87	169,650	13
Mississippi	313,000	53,210	17	297,350	95	15,650	5
Texas	5,450,000	1,308,000	24	3,924,000	72	1,526,000	28
Arkansas	2,290,000	687,000	30	1,946,500	85	343,500	15
Tennessee	9,595,000	2,686,600	28	5,469,150	57	4,125,850	43
West Virginia	2,840,000	908,800	32	1,874,400	66	965,600	34
Kentucky	11,113,000	2,667,120	24	6,667,800	60	4,445,200	40
Ohio	35,895,000	10,768,500	30	16,152,750	45	19,742,250	55
Michigan	21,672,000	6,284,880	29	7,801,920	36	13,870,080	64
Indiana	37,828,000	10,591,840	28	13,618,080	36	24,209,920	64
Illinois	36,861,000	8,846,640	24	13,638,570	37	23,222,430	63
Wisconsin	13,063,000	4,833,310	37	7,315,280	56	5,747,720	44
Minnesota	36,299,000	10,889,700	30	9,800,730	27	26,498,270	73
Iowa	26,837,000	9,392,950	35	19,054,270	71	7,782,730	29
Missouri	27,744,000	7,490,880	27	15,536,640	56	12,207,360	44
Kansas	7,607,000	2,053,890	27	4,564,200	60	3,042,800	40
Nebraska	16,585,000	5,307,200	32	8,624,200	52	7,960,800	48
California	30,429,000	8,520,120	28	8,215,830	27	22,213,170	73
Oregon	16,100,000	4,830,000	30	4,830,000	30	11,270,000	70
Nevada	111,000	32,190	29	88,800	80	22,200	20
Colorado	2,514,000	678,780	27	1,106,160	44	1,407,840	56
Arizona	303,000	78,780	26	239,370	79	63,630	21
Dakota	52,406,000	14,149,620	27	9,957,140	19	42,448,860	81
Idaho	1,120,000	336,000	30	784,000	70	336,000	30
Montana	1,760,000	492,800	28	1,020,800	58	739,200	42
New Mexico	1,221,000	329,670	27	1,050,060	86	170,940	14
Utah	1,971,000	650,430	33	1,182,600	60	788,400	40
Washington	8,345,000	2,586,950	31	5,424,250	65	2,920,750	35
Total	456,329,000	132,094,880	28.9	200,162,800	43.9	256,166,200	56.1

Average price of wheat for the years 1875–'87.

States.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.
Kentucky	$1.05	$1.00	$0.99	$0.76	$1.08	$0.93	$1.31	$0.90	$0.95	$0.74	0.95	$0.72	$0.73
Ohio	1.09	1.14	1.24	.86	1.20	1.02	1.29	.95	.99	.75	.91	.74	.75
Michigan	1.15	1.16	1.22	.85	1.17	.97	1.25	.90	.96	.74	.84	.73	.74
Indiana	.97	1.02	1.13	.81	1.17	.99	1.27	.90	.95	.67	.86	.70	.72
Illinois	.91	.93	1.04	.75	1.07	.95	1.22	.86	.92	.63	.81	.69	.70
Wisconsin	.91	1.01	.93	.67	1.04	1.00	1.19	.90	.88	.60	.76	.68	.64
Minnesota	.86	.90	.91	.51	.94	.87	1.06	.82	.80	.50	.70	.61	.59
Iowa	.71	.90	.87	.50	.92	.82	1.06	.70	.80	.55	.67	.60	.61
Missouri	.95	.89	1.00	.67	1.01	.89	1.19	.85	.88	.62	.77	.63	.62
Kansas	.87	.86	.82	.59	.89	.70	1.05	.67	.78	.45	.65	.58	.61
Nebraska	.64	.73	.83	.49	.84	.73	.97	.67	.70	.42	.57	.47	.53
Dakota	......	......	......	......	......	......	......	.80	.72	.46	.63	.52	.52
United States	1.00	1.037	1.082	.777	1.108	.951	1.193	.882	.911	.645	.771	.687	.681

The average export price is as follows for twelve years:

Year ended June 30—	Average price.	Year ended June 30—	Average price.
1875	$1.12	1882	$1.19
1876	1.24	1883	1.13
1877	1.17	1884	1.07
1878	1.34	1885	.86
1879	1.07	1886	.87
1880	1.24	1887	.89
1881	1.11		

The farm value of the wheat crop of 1887 was $310,612,960, as reported in December, averaging 68.1 cents per bushel; but the export wheat, coming from the Northwest mainly, had a probable farm value, as delivered by the growers, of about 59 cents per bushel.

WEIGHT PER BUSHEL.

The average weight of the crop is slightly increased, scoring the highest point for several years, 58.5 pounds per measured Winchester bushel. The record for the crop of 1886 was 58.4; for 1885 it was 57 pounds; for 1884 it was 58.3 pounds; and for 1883 it was 56.9 pounds. This makes an equivalent of 445,047,538 bushels of 60 pounds each.

In fixing the averages for States, estimates have been received from three sources: (1) from county correspondents, (2) from State agents, (3) from millers. In most cases there was a reasonable agreement. Where discrepancies occurred, they were harmonized in accordance with the history of crop conditions affecting quality. The millers have the best opportunity to test weights, and if they know how their takings compare with the body of wheat of all grades, their judgment is entitled to preference; they do not always agree, however, in their estimates.

Weight per bushel.

States and Territories.	Weight per bushel.	Bushels of crop.	Weight.	Bushels of 60 pounds.
	Pounds.		*Pounds.*	
Maine	56	481,000	26,936,000	448,933
New Hampshire	56	110,000	6,160,000	102,667
Vermont	57	320,000	18,240,000	304,000
Massachusetts	58	16,000	928,000	15,467
Connecticut	57.5	37,000	2,127,500	35,458
New York	57.5	10,137,000	582,877,500	9,714,625
New Jersey	58	1,459,000	84,622,000	1,410,367
Pennsylvania	57.6	13,785,000	794,016,000	13,233,600
Delaware	57	929,000	52,953,000	882,550
Maryland	57.5	5,797,000	333,327,500	5,555,458
Virginia	58	4,832,000	280,256,000	4,670,933
North Carolina	58	5,094,000	295,452,000	4,924,200
South Carolina	58.5	1,233,000	72,130,500	1,202,175
Georgia	57	2,522,000	143,754,000	2,395,900
Alabama	58	1,305,000	75,690,000	1,261,500
Mississippi	59	313,000	18,467,000	307,783
Texas	58	5,450,000	316,100,000	5,268,333
Arkansas	58	2,290,000	132,820,000	2,213,667
Tennessee	59	9,595,000	566,105,000	9,435,083
West Virginia	59	2,840,000	167,560,000	2,792,667
Kentucky	58.5	11,113,000	650,110,500	10,835,175
Ohio	59	35,895,000	2,117,805,000	35,296,750
Michigan	59	21,672,000	1,278,648,000	21,310,800
Indiana	59.5	37,828,000	2,250,766,000	37,512,767
Illinois	59.5	36,861,000	2,193,229,500	36,553,825
Wisconsin	57.3	13,063,000	748,509,900	12,475,165
Minnesota	57.8	36,299,000	2,098,082,200	34,968,037
Iowa	57	26,837,000	1,529,709,000	25,495,150
Missouri	59.5	27,744,000	1,650,768,000	27,512,800
Kansas	57	7,607,000	433,599,000	7,226,650
Nebraska	57	16,585,000	945,345,000	15,755,750
California	59	30,429,000	1,795,311,000	29,921,850
Oregon	59.7	16,100,000	961,170,000	16,019,500
Nevada	59.5	111,000	6,604,500	110,075
Colorado	59.5	2,514,000	149,583,000	2,493,050
Arizona	57.5	303,000	17,422,500	290,375
Dakota	58.2	52,406,000	3,050,029,200	50,833,820
Idaho	58.5	1,120,000	65,520,000	1,092,000
Montana	58.3	1,760,000	102,608,000	1,710,133
New Mexico	59	1,221,000	72,039,000	1,200,650
Utah	59.5	1,971,000	117,274,500	1,954,575
Washington	59.7	8,345,000	498,196,500	8,303,275
Total	58.5	456,329,000	26,702,852,300	445,047,538

It is seen that the heaviest wheat is that of Indiana and Illinois, the Rocky Mountains and Pacific coast.

OATS.

The increase of the area of oats has been greater than that of corn or wheat, and still there is no surplus. The average was 11,000,000 acres for 1870–'79, and 21,000,000 for 1880–'87. The averages of yield per acre, respectively, 28.4 and 26.5 bushels, a small decrease, while the increase of aggregate product has been 74.5 per cent. The enlarged supply has reduced the average of price per bushel from 35.3 to 32.8 cents, and the average value per acre from $10.03 to $8.71. The use of oatmeal as food for man has enlarged the demand for oats, and the necessity of partial substitution of oats for corn in the feeding of horses in the South is steadily enlarging the requirement in that direction. The area has increased proportionally more than that of wheat or corn, and the price has declined less, showing the need of a larger supply than formerly for domestic consumption. This fact has the greater significance, as it exists without any appreciable foreign demand. The decline in value per acre in a comparison of the period is 13.2 per cent. for oats, 14.9 per cent. for corn, and 22.6 per cent. for wheat, according to the following table:

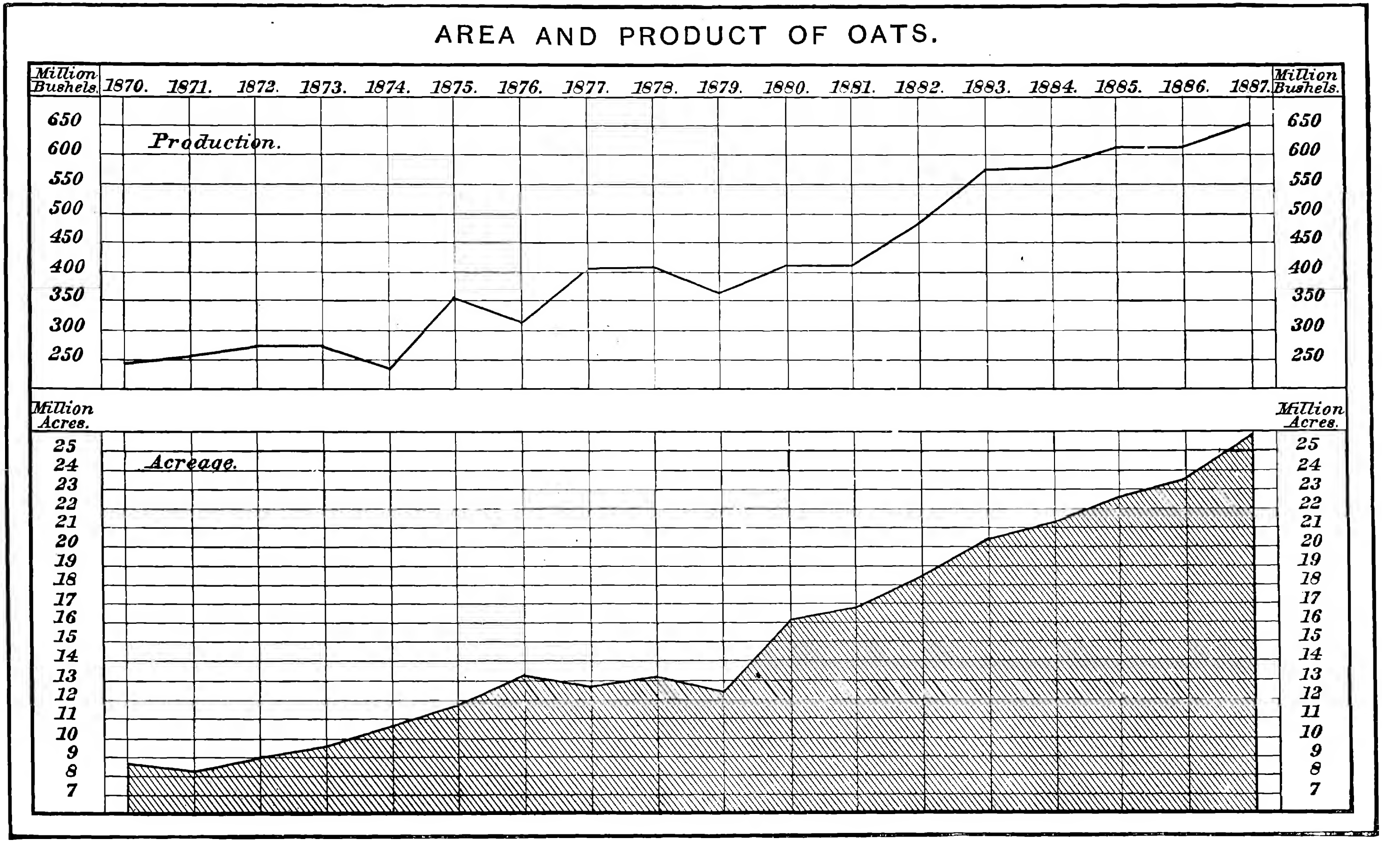
Years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value per acre.
	Bushels.	*Acres.*		*Cents.*	*Bushels.*	
1880	417,885,380	16,187,977	$150,243,565	36.0	25.8	$9.28
1881	416,481,000	16,831,600	193,198,970	46.4	24.7	11.48
1882	488,250,610	18,494,691	182,978,022	37.5	26.4	9.64
1883	571,302,400	20,324,962	187,040,264	33.0	28.1	9.27
1884	583,628,000	21,300,917	161,528,470	28.0	27.4	7.58
1885	629,409,000	22,783,630	179,631,860	28.5	27.6	7.88
1886	624,134,000	23,658,474	186,137,930	29.8	26.4	7.87
1887	659,618,000	25,920,906	200,699,790	30.4	25.4	7.74
Total	4,390,708,390	165,503,157	1,441,458,871	....	....	....
Annual average	548,838,549	20,687,895	180,182,359	32.8	26.5	8.71
Annual average for preceding ten years	314,441,178	11,076,822	111,075,223	35.3	28.4	10.03

For oats, as in the case of corn, the uses are so many and various, for man and beast, that its consumption is elastic, depending much on price, while the restriction of wheat to one use, as food for man, with a demand uniform and not to be extended, subjects that grain to the inevitable and severe operation of the law by which quantity controls price. The area, product, and value of oats, by States, for 1887, is as follows:

States and Territories.	Acres.	Bushels.	Value.
Maine	93,205	2,684,000	$1,127,280
New Hampshire	33,749	965,000	414,950
Vermont	107,723	2,736,000	1,094,400
Massachusetts	24,752	703,000	302,290
Rhode Island	6,353	165,000	70,950
Connecticut	39,417	1,088,000	456,960
New York	1,413,088	33,208,000	12,286,960
New Jersey	138,830	3,221,000	1,159,560
Pennsylvania	1,330,234	33,921,000	11,872,350
Delaware	21,623	458,000	151,140
Maryland	117,798	2,438,000	804,540
Virginia	652,665	11,095,000	3,883,250

Report of the Statistician, U. S. Department of Agriculture, 1887.

DIAGRAM C.



States and Territories.	Acres.	Bushels.	Value.
North Carolina	654,116	8,504,000	$3,741,760
South Carolina	397,198	4,607,000	2,718,130
Georgia	612,561	7,044,000	4,085,520
Florida	52,493	761,000	456,600
Alabama	422,101	4,643,000	2,692,940
Mississippi	358,551	4,410,000	2,513,700
Louisiana	36,861	438,000	263,940
Texas	580,614	12,193,000	4,511,410
Arkansas	269,125	4,710,000	1,884,000
Tennessee	645,086	9,225,000	3,505,500
West Virginia	142,207	2,531,000	885,850
Kentucky	491,496	8,847,000	3,007,980
Ohio	1,003,278	30,098,000	9,631,360
Michigan	765,000	22,644,000	7,246,080
Indiana	1,034,923	27,943,000	8,103,470
Illinois	3,690,385	108,866,000	29,393,820
Wisconsin	1,440,299	34,855,000	9,759,400
Minnesota	1,354,532	40,636,000	10,565,360
Iowa	2,428,746	74,382,000	17,851,680
Missouri	1,358,119	39,793,000	10,346,180
Kansas	1,505,251	40,041,000	11,611,890
Nebraska	922,369	25,365,000	5,326,650
California	81,955	2,196,000	1,273,680
Oregon	203,183	5,547,000	2,218,800
Nevada	7,858	196,000	98,000
Colorado	50,617	1,569,000	706,050
Dakota	1,186,800	37,266,000	9,316,500
Idaho	36,509	1,095,000	492,750
Montana	60,180	1,866,000	839,700
New Mexico	15,389	362,000	166,520
Utah	29,658	786,000	337,980
Washington	91,045	3,369,000	1,482,360
Wyoming	2,921	88,000	39,600
Total	25,920,906	659,618,000	200,699,790

An illustration of the rapid increase of area and enlargement of production is found in the accompanying Diagram C.

COTTON.

There has been steady progress in cotton-growing, interrupted only for four years, 1861 to 1865, starting anew with free labor in the latter year, and producing about half as much as in 1860. It was not until 1870 that the product obtained before the war was closely approximated, and not fully reached until 1875. In the past twelve years the increase has been more than 50 per cent. It is assumed by those best qualified to judge that the area of 1859 was about 12,000,000 acres. The present acreage is believed to exceed 18,000,000 acres. In 1879, by the census enumeration, it was nearly 14,500,000 acres. According to estimates of this Department it is distributed as follows:

States.	1886.	1887.
	Acres.	*Acres.*
Virginia	42,667	40,334
North Carolina	1,071,658	1,066,301
South Carolina	1,655,291	1,622,185
Georgia	2,956,267	2,941,486
Florida	270,738	262,616
Alabama	2,823,718	2,809,599
Mississippi	2,548,674	2,548,674
Louisiana	1,035,781	1,066,854
Texas	3,771,740	3,960,327
Arkansas	1,354,788	1,388,658
Tennessee	847,326	855,799
Missouri	75,955	78,234
Total	18,454,603	18,641,067

The crop of 1887 was planted earlier than any in recent years, had a good stand, and a vigorous early growth, and in July a higher condition was reported than for ten years, averaging 97, giving promise of nearly 8,000,000 bales. During July excessive rains on the Atlantic coast and drought in the Gulf States reduced this average to 93.3. This was only the beginning of the reduction, which was continued through August and September to 82.8 and 76.5. The decline was alarming, and while it was real and very heavy, the general depression caused by it probably gave some slight bias to the judgment of the reporters, reducing the general average a point or two below its real effect.

From October forward the meteorological conditions were remarkably favorable, frost was delayed, the growing season lengthened, the weather for picking favorable, increasing the crop at least a third of a million bales beyond the reasonable expectation in October. The result is a crop only exceeded by that of 1882, when nearly 7,000,000 bales were gathered.

Diagram D presents an illustration of the progress of cotton growing since 1841. The dark perpendicular bands in the diagram represent the quantity exported, while the lighter extensions show the quantity used at home.

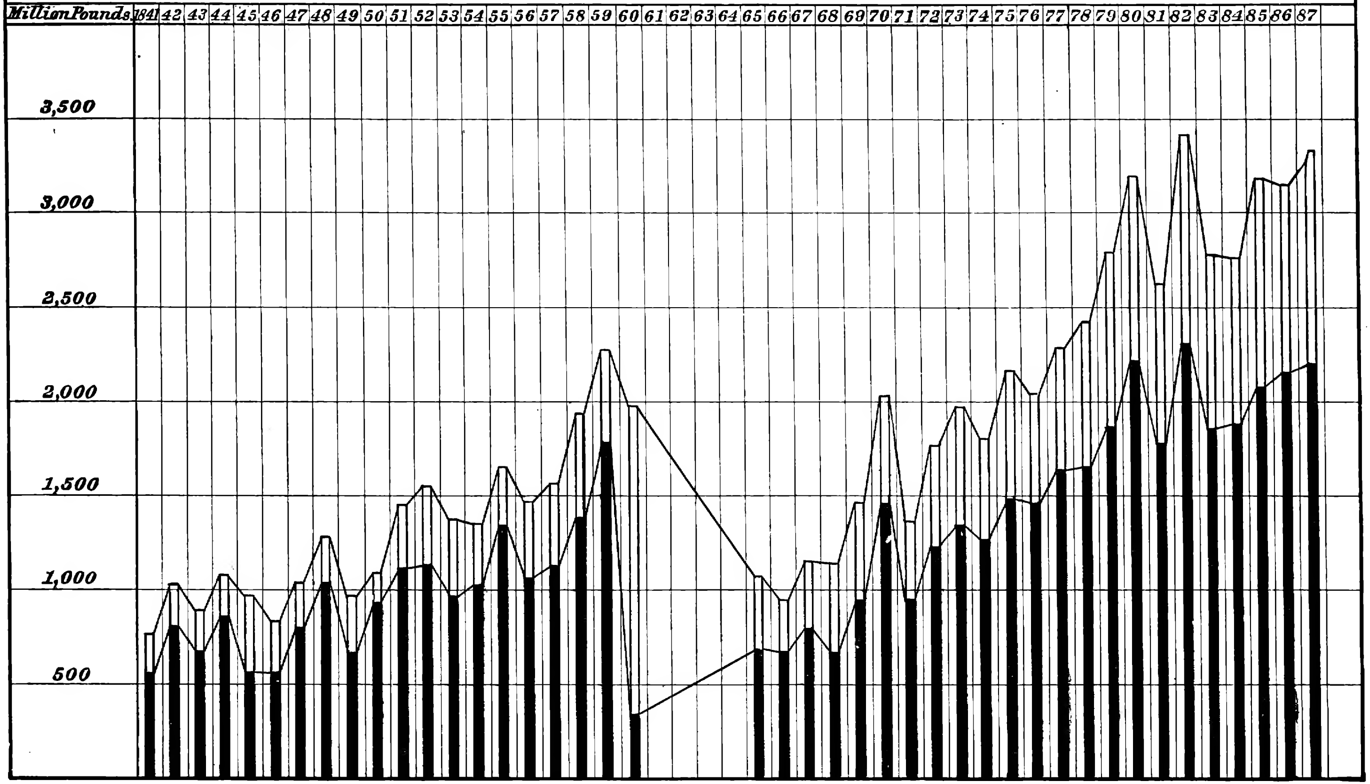
The average annual production of twenty years before 1861 was therefore 1,335,000,000 pounds, and of the twenty-three years since 1865 it was 2,207,000,000 pounds, an increase of 65.3 per cent. This is not an increase proportionate to our increase of population, because the consumption of cotton is not expected to enlarge with the numbers of people in this country, but with the requirements of the world.

The exportation of the first period averages 929,000,000 pounds, and of the second 1,492,000,000 pounds, an increase of 60.6 per cent. The increase of home manufacture has therefore been proportionately greater than that of production:

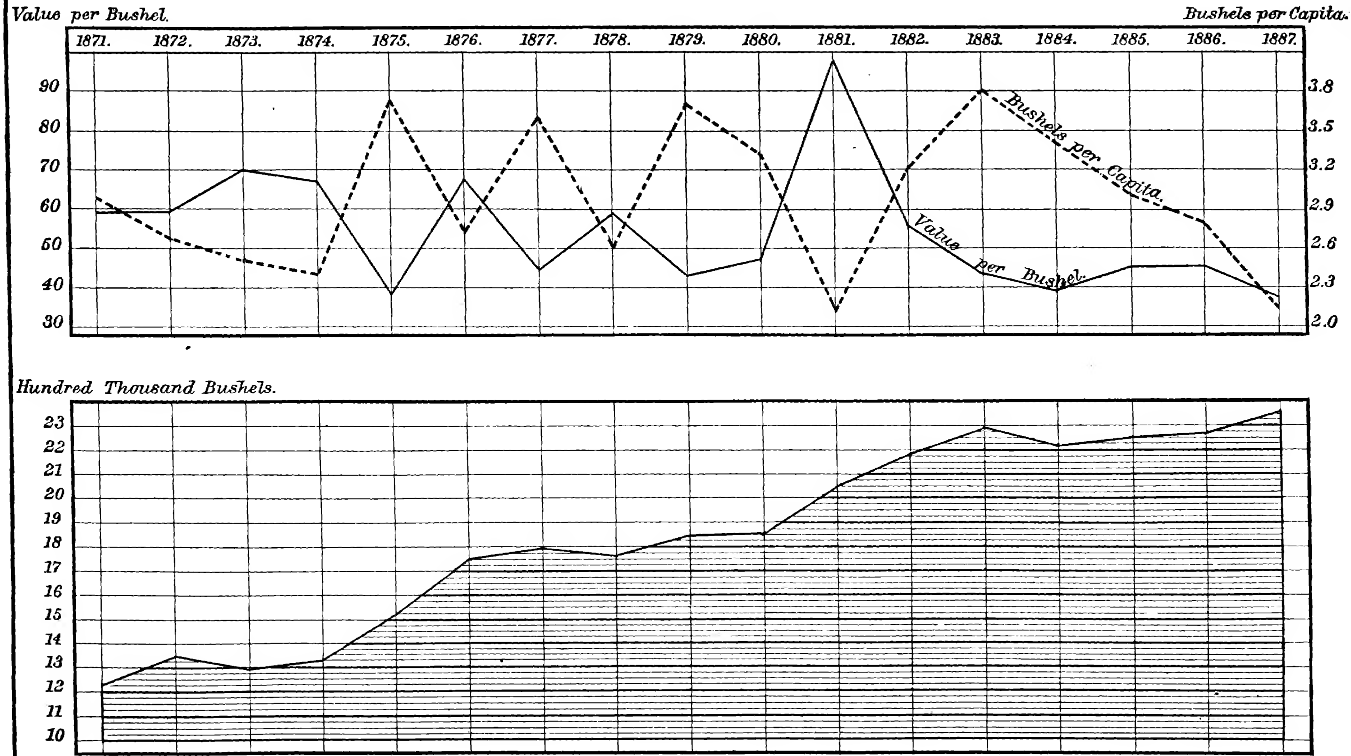
Years.	Production.	Exports.	Years.	Production.	Exports.
	Pounds.	*Pounds.*		*Pounds.*	*Pounds.*
1841	759,903,750	584,717,017	1865	1,041,962,263	650,572,829
1842	1,077,391,350	792,297,106	1866	969,175,303	661,473,588
1843	948,860,550	663,633,455	1867	1,173,431,114	784,763,633
1844	1,118,097,900	872,905,996	1868	1,129,811,645	644,327,921
1845	976,741,650	547,558,055	1869	1,451,401,357	958,558,523
1846	837,215,550	527,219,958	1870	2,020,693,736	1,462,928,024
1847	1,090,850,850	814,274,431	1871	1,384,084,494	933,537,413
1848	1,263,868,200	1,026,602,269	1872	1,833,188,931	1,200,063,530
1849	977,267,700	635,381,604	1873	1,940,648,352	1,358,602,303
1850	1,036,865,650	927,237,089	1874	1,783,644,032	1,260,418,903
1851	1,421,413,340	1,093,230,639	1875	2,157,958,142	1,491,405,334
1852	1,542,325,720	1,111,570,370	1876	2,095,901,297	1,445,369,130
1853	1,396,112,420	987,833,106	1877	2,260,285,666	1,607,533,511
1854	1,363,537,635	1,008,424,601	1878	2,404,410,373	1,628,372,833
1855	1,658,631,975	1,351,431,701	1879	2,771,797,156	1,822,061,114
1856	1,467,129,120	1,048,282,475	1880	3,199,822,682	2,190,928,772
1857	1,554,701,760	1,118,624,012	1881	2,588,236,636	1,739,975,961
1858	1,949,306,728	1,386,468,562	1882	3,405,070,410	2,288,075,062
1859	2,274,372,309	1,767,686,338	1883	2,757,544,422	1,862,572,530
1860	1,934,545,603	307,516,099	1884	2,742,966,011	1,891,659,472
			1885	3,182,350,531	2,058,037,444
Total	26,699,139,760	18,572,804,883	1886	3,157,378,443	2,169,457,330
			1887*	3,300,000,000	2,200,000,000
			Total	50,751,762,996	34,310,695,160

* Approximate.

PRODUCT AND EXPORT OF COTTON.—1841 TO 1887.



POTATOES.—EFFECT OF QUANTITY ON PRICES.



IRISH POTATOES.

The crop of 1887 was unfortunate from the start. Disaster attended it during its season of growth. New England alone gave promise of a fair crop early in the season, which was succeeded by unfavorable conditions and disappointment.

In the States west of the Alleghany Mountains the crop year opened most unfavorably, drought prevailing over a large part of the area, interfering with germination and retarding growth. The drought continued generally unbroken until the season was too far advanced to make more than a fraction of a crop possible. In the Eastern and Middle States prospects were favorable for a good crop until August, when excessive moisture was followed by a tendency to rot, and condition steadily declined.

The area of potatoes was enlarged, the preliminary estimate showing more than 2,300,000 acres. The increase was largest in the more western States, though considerable in the older States, where the previous crop had proved more profitable than the cereals. The preliminary estimate was 134,000,000 bushels in round numbers, the figures being subject to slight modification in the final record by States. The record of eight years is:

Year.	Acres.	Per acre.	Product.
		Bushels.	*Bushels.*
1880	1,842,510	91.0	167,659,570
1881	2,041,670	53.5	109,145,494
1882	2,171,636	78.7	170,972,508
1883	2,289,275	91.0	208,164,425
1884	2,220,980	85.8	190,642,000
1885	2,265,823	77.2	175,029,000
1886	2,287,136	73.5	168,051,000
1887	*2,300,000	....	134,000,000

*Approximate.

The crop of 1879, according to the census of 1880, amounted to 169,458,539 bushels, of which six States, New York, Pennsylvania, Ohio, Michigan, Indiana, and Illinois produced 56 per cent. The crop of these States was last year reduced nearly one-half.

Diagram E illustrates the progress of potato growing, showing the area by superficial measurement, and the effect of relative supply upon market price by linear exhibits.

FLAX.

Flax growing is one of the minor agricultural industries, and while the production of seed, for which it is almost entirely grown, varies from year to year in different localities, the total product is but little changed. In order to determine approximately its present extent, and the areas where it is now grown, the Department has made a thorough investigation, and presents its results in connection with statements showing commercial distribution and supply.

It is essentially a pioneer crop and has never been long popular in any one locality. For new land, brought under the plow for the first time, it is almost unequaled as a crop for subduing the natural wildness of the land, and being, like wheat, a ready money crop, it is for a time in high favor with poineer settlers. The center of production follows westward the frontier line of farming lands, its cultivation in the older regions gradually giving way to other and more perma-

nently popular crops. In the older areas there is a decided prejudice toward it on account of injury to fertility of the soil, but new settlers in the West and Northwest, with their deep rich soils, can and do disregard this objection.

It is undoubtedly true that flax does very rapidly withdraw certain constituent elements from the soil, the presence of which is necessary to its successful production, but the same may be said of other crops which are always in favor. Were it desired American farmers could easily devise means to renew the elements withdrawn, so a further reason for its comparative abandonment in the older sections must be sought. Under present conditions it is not a paying crop, except on the fertile virgin soils of portions of the trans-Mississippi States. This is variously accounted for by correspondents, but the main cause is undoubtedly the fact that there is no general demand for anything except the seed, the straw and the fiber going almost entirely to waste on account of lack of facilities for its utilization. In a few localities in the more eastern States the fiber is used in rough bagging and rope making, and there are a few establishments where it is converted into tow for upholstering; many correspondents in Minnesota, Iowa, and Kansas speak of the straw as being fed to cattle to a considerable extent as a substitute for straw and corn fodder, and others of its use as a material for thatching houses and cattle shelters, but as a general rule the straw and fiber together are burned or returned to the soil as a dressing. In primitive days, before the development of our cotton and wool-manufacturing industries and transportation facilities, the hackel and brake and the spinning-wheel and hand-loom were implements almost as necessary to the farmer as the plow and flail.

The present investigation, relating mainly to seed, shows that the crop of 1887, while considerably smaller than that of the previous year, is somewhat larger than that of 1879. Its production is confined to that great belt of States lying north of the thirty-seventh parallel and west of Ohio. The ten principal States of this region in 1879 produced 97 per cent. of the total seed grown, and the proportion remains about the same, though the center of production has shifted to the extreme western limit of the belt. The following statement shows the production of seed in 1879, according to the returns of the Tenth Census, and in comparison the estimated production of 1887, as ascertained by this investigation:

States.	1879.	1887.	States.	1879.	1887.
	Bushels.	*Bushels.*		*Bushels.*	*Bushels.*
Ohio	593,217	118,643	Kansas	513,616	1,068,321
Indiana	1,419,172	113,534	Nebraska	77,805	665,233
Illinois	1,812,438	94,247	Dakota	26,757	3,237,597
Wisconsin	547,101	65,652	All other	191,487	142,258
Minnesota	98,689	1,246,442			
Iowa	1,511,131	1,888,914	Total	7,170,951	9,001,399
Missouri	379,535	360,558			

The most remarkable feature of this table is the marked falling off of the crop of the more Eastern States and the still more extraordinary increase in the Western belt. In 1879 the four States east of the Mississippi River produced 63 per cent. of the total of the States named, while in the present year the same region grows but little more than 4 per cent. of the whole, the six trans-Mississippi States

producing considerably more than nine-tenths of all. Even in this region the industry is now beginning to decline, and the causes given by correspondents are the same as have caused its virtual abandonment farther east. Many returns from Iowa and Wisconsin agree that under existing conditions it is not a profitable crop, being very hard on any but fresh soil, and the seed alone not paying for its growth.

In connection with the above estimate for 1887, a table has been compiled from returns of State boards of agriculture or assessors' returns for the flax States, showing, in comparison with the census returns for 1879, the acreage and product of seed in 1885 and 1886 and the estimated acreage of the present year. The Department does not hesitate to say that it believes these State returns generally too low—on the whole perhaps 10 per cent. below the truth—on account of the almost universal tendency of assessors to underrate both acreage and product.

States.	Bushels of seed (census returns), 1879.	State returns.				
		Acres, 1885	Bushels of seed, 1885.	Acres, 1886.	Bushels of seed, 1886	Acres, 1887.
Ohio	593,217	16,680	143,781	....	....	....
Indiana	1,419,172	21,977	161,681	18,268	153,128	14,000
Illinois	1,812,438	21,744	198,823	13,231	117,593	10,184
Wisconsin	547,104	....	88,219	9,707	....	....
Minnesota	98,689	....	2,246,077	204,147	1,508,771	170,225
Iowa	1,511,131	303,708	2,663,073	291,560	2,332,480	271,161
Kansas	513,616	122,199	819,949	87,904	879,040	132,580
Nebraska	77,805	65,728	627,254	....	....	....
Dakota	26,757	364,823	2,916,983	549,189	3,844,323	366,126

Chicago, Saint Louis, and Milwaukee are the great flaxseed markets and our correspondents generally speak of their products as going directly or indirectly to these great marts. There are scattered through the producing region numbers of local oil-mills, which take a portion of the crop without the expense of long shipments, but the bulk of the crop finally reaches some of the great central markets. In Ohio, Indiana, and Illinois mills which formerly consumed a considerable portion of the local grown seed have been compelled to go out of the business on account of the refusal of farmers to grow it for them, and for others yet running it is only grown by cultivators to whom the mill-men lend the seed for sowing, the planters taking too little interest to preserve their own seed.

The receipts and shipments of seed in the three principal Western markets for a series of years is thus shown:

Year.	Chicago.		Milwaukee.		Saint Louis.	
	Receipts.	Shipments.	Receipts.	Shipments.	Receipts.	Shipments.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
1882	4,923,091	4,332,047	1,104,663	944,637	1,260,727	656,952
1883	3,079,285	3,003,591	911,816	890,218	884,434	342,672
1884	3,679,530	3,033,812	1,207,499	1,044,159	536,009	141,377
1885	6,770,657	5,567,526	2,280,855	2,183,750	436,105	102,775
1886	7,092,573	6,692,590	2,298,952	2,217,429	366,202	57,284

The home product of flaxseed is never equal to the home consumption, large quantities being annually imported. The principal source of supply is the British East Indies, from whence we receive more than 90 per cent. of our foreign supply. The importations of seed since 1878 have been as follows:

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Bushels.			*Bushels.*	
1878	1,290,615	$1,883,333	1883	637,729	$677,040
1879	1,009,261	1,613,001	1884	2,849,226	3,079,848
1880	1,464,195	2,261,049	1885	2,548,864	2,817,715
1881	908,191	1,250,580	1886	1,034,576	1,099,477
1882	635,079	773,044	1887	415,179	418,202

This, however, is but a small portion of what we annually send abroad for the products of flax and other similar fiber plants, the larger proportion of which it seems might properly be produced at home. The imports of flax, hemp, jute, and other similar substances, and their manufactured products during the past two years, were as follows:

Articles.	1886.		1887.	
	Quantity.	Value.	Quantity.	Value.
Unmanufactured:	*Tons.*		*Tons.*	
Flax	5,557	$1,576,518	7,140	$1,922,182
Hemp and substitutes	28,655	3,817,376	32,739	4,041,522
Jute	83,054	2,267,023	88,514	2,616,128
Sisal grass, etc	35,300	2,299,450	36,355	3,733,001
Total	152,566	9,960,367	164,748	12,312,833
Manufactures of flax, hemp, or jute, etc		20,963,135		21,930,592

It would seem that there is a large field open to the enterprising American farmer and the skillful mechanic in devising means by which the large portion of this crop, which now goes to waste, shall be successfully utilized.

CROP ESTIMATES FOR 1886.

Table showing the product of the cereals, potatoes, tobacco, hay, and cotton of the several States named, the yield per acre, the total acreage, the average price in each State, and the value of each crop for 1886.

States.	Products.	Quantity produced in 1886.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Maine	Indian corn....bushels	989,000	31.4	31,534	$0.67	$662,630
	Wheat....do	600,000	14.4	41,537	1.20	720,000
	Rye....do	29,000	12.2	2,385	.88	25,520
	Oats....do	2,701,000	29.8	90,490	.40	1,080,400
	Barley....do	252,000	22.5	11,206	.65	163,800
	Buckwheat....do	362,000	18.0	20,126	.55	199,100
	Potatoes....do	6,514,000	105	62,035	.55	3,582,700
	Hay....tons	1,103,610	.86	1,286,874	11.60	12,801,876
	Total			1,546,187		19,236,026

Table showing the product of the cereals, potatoes, tobacco, hay, etc.—Continued.

States.	Products.	Quantity produced in 1886.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
New Hampshire...	Indian corn....bushels..	1,364,000	35.4	38,578	$0.68	$927,520
	Wheat...........do....	169,000	15.2	11,154	1.18	199,420
	Rye..............do....	38,000	11.4	3,346	.87	33,060
	Oats.............do....	1,081,000	33.0	32,766	.41	443,210
	Barley...........do....	89,000	23.1	3,857	.68	60,520
	Buckwheat.......do....	92,000	19.2	4,784	.57	52,440
	Potatoes.........do....	2,813,000	102	27,577	.47	1,322,110
	Hay..............tons..	548,256	.81	678,730	12.00	6,579,072
	Total............	....	....	800,792	....	9,617,352
Vermont	Indian corn....bushels..	2,058,000	32.8	62,718	.66	1,358,280
	Wheat...........do....	410,000	19.0	21,567	1.10	451,000
	Rye..............do....	82,000	13.0	6,290	.73	59,860
	Oats.............do....	3,844,000	36.0	106,656	.37	1,422,280
	Barley...........do....	304,000	26.0	11,711	.63	191,520
	Buckwheat.......do....	359,000	20.1	17,862	.53	190,270
	Potatoes.........do....	3,763,000	104	36,185	.38	1,429,940
	Hay..............tons..	965,889	.94	1,023,060	10.40	10,045,246
	Total............	....	....	1,286,049	....	15,148,396
Massachusetts.....	Indian corn....bushels..	1,922,000	32.7	58,821	.66	1,268,520
	Wheat...........do....	17,000	15.7	1,080	1.00	17,000
	Rye..............do....	326,000	13.0	25,053	.70	228,200
	Oats.............do....	738,000	30.4	24,267	.44	324,720
	Barley...........do....	75,000	23.1	3,248	.70	52,500
	Buckwheat.......do....	92,000	17.4	5,281	.62	57,040
	Potatoes.........do....	3,425,000	101	33,912	.62	2,123,500
	Tobacco.........pounds..	4,231,000	1,631	2,594	.14	592,340
	Hay..............tons..	661,077	1.04	635,893	17.00	11,238,309
	Total............	....	....	790,149	....	15,902,129
Rhode Island	Indian corn....bushels..	408,000	31.5	12,946	.67	273,360
	Rye..............do....	19,000	13.8	1,372	.72	13,680
	Oats.............do....	184,000	29.0	6,353	.44	80,960
	Barley...........do....	21,000	25.5	824	.71	14,910
	Buckwheat.......do....	2,000	15.7	127	.65	1,300
	Potatoes.........do....	649,000	100	6,493	.63	408,870
	Hay..............tons..	78,016	.81	95,778	16.80	1,310,669
	Total............	....	....	123,893	....	2,103,749
Connecticut	Indian corn....bushels..	1,992,000	34.3	58,140	.63	1,254,960
	Wheat...........do....	36,000	16.4	2,193	.98	35,280
	Rye..............do....	390,000	13.0	29,981	.67	261,800
	Oats.............do....	1,123,000	28.8	39,027	.42	471,660
	Barley...........do....	14,000	22.2	632	.62	8,680
	Buckwheat.......do....	147,000	13.5	10,865	.56	82,320
	Potatoes.........do....	2,208,000	70	31,541	.60	1,324,800
	Tobacco.........pounds..	11,667,000	1,600	7,292	.14	1,633,380
	Hay..............tons..	540,402	.94	574,649	15.10	8,160,070
	Total............	....	....	754,320	....	13,232,450
New York	Indian corn....bushels..	22,426,000	31.3	716,572	.56	12,558,560
	Wheat...........do....	11,093,000	16.3	680,493	.84	9,318,120
	Rye..............do....	2,890,000	12.2	236,875	.59	1,705,100
	Oats.............do....	40,223,000	28.7	1,399,097	.35	14,078,050
	Barley...........do....	7,712,000	22.0	350,544	.61	4,704,320
	Buckwheat.......do....	4,543,000	14.3	317,663	.52	2,362,360
	Potatoes.........do....	27,995,000	80	349,934	.41	11,477,950
	Tobacco.........pounds..	7,583,000	1,300	5,833	.115	872,045
	Hay..............tons..	5,418,677	1.06	5,111,023	10.75	58,250,778
	Total............	....	....	9,168,034	....	115,327,283
New Jersey........	Indian corn....bushels..	9,418,000	27.1	346,866	.50	4,709,000
	Wheat...........do....	2,260,000	15.6	144,528	.86	1,943,600
	Rye..............do....	1,232,000	11.9	103,518	.57	702,240
	Oats.............do....	3,734,000	27.2	137,455	.36	1,344,240
	Buckwheat.......do....	453,000	12.8	35,376	.59	267,270
	Potatoes.........do....	3,208,000	80	40,098	.54	1,732,320
	Hay..............tons..	517,943	1.03	503,664	13.00	6,733,259
	Total............	....	....	1,311,505	....	17,431,929

Table showing the product of the cereals, potatoes, tobacco, hay, etc.—Continued.

States.	Products.	Quantity produced in 1886.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Pennsylvania......	Indian corn....bushels..	40,545,000	28.2	1,438,285	$0.47	$19,056,150
	Wheat...........do....	18,255,000	12.7	1,435,506	.83	15,151,650
	Rye..............do....	4,545,000	11.3	402,179	.58	2,636,100
	Oats.............do....	37,759,000	28.7	1,317,063	.34	12,838,060
	Barley...........do....	505,000	18.0	28,065	.60	303,000
	Buckwheat.......do....	3,513,000	12.8	274,445	.54	1,897,020
	Potatoes.........do....	14,606,000	76	192,183	.46	6,718,760
	Tobacco.......pounds..	34,951,000	1,218	28,695	.118	4,124,218
	Hay.............tons..	3,067,201	1.13	2,711,186	11.50	35,272,812
	Total............	....	....	7,827,607	....	97,997,770
Delaware..........	Indian corn....bushels..	3,590,000	16.6	216,595	.42	1,507,800
	Wheat...........do....	1,177,000	12.4	94,790	.84	988,680
	Rye..............do....	6,000	7.0	857	.60	3,600
	Oats.............do....	492,000	23.0	21,409	.35	172,200
	Buckwheat.......do....	6,000	13.7	437	.57	3,420
	Potatoes.........do....	272,000	65	4,182	.50	136,000
	Hay.............tons....	50,025	.99	50,621	12.25	612,806
	Total............	....	....	388,891	....	3,424,506
Maryland..........	Indian corn....bushels..	15,039,000	20.9	719,073	.43	6,466,770
	Wheat...........do....	7,194,000	12.3	586,287	.82	5,899,080
	Rye..............do....	258,000	8.4	30,750	.60	154,800
	Oats.............do....	2,470,000	21.8	113,322	.33	815,100
	Buckwheat.......do....	131,000	12.0	10,894	.62	81,220
	Potatoes.........do....	1,393,000	67	20,786	.46	640,780
	Tobacco.......pounds..	25,238,000	575	43,892	.065	1,640,470
	Hay.............tons..	312,843	1.08	289,219	11.50	3,597,695
	Total............	....	....	1,814,223	....	19,295,915
Virginia..........	Indian corn...bushels..	32,793,000	15.5	2,110,908	.45	14,756,850
	Wheat...........do....	5,581,000	8.2	683,697	.81	4,520,610
	Rye..............do....	385,000	7.5	51,327	.62	238,700
	Oats.............do....	8,577,000	13.5	633,655	.34	2,916,180
	Barley...........do....	21,000	18.2	1,151	.63	13,230
	Buckwheat.......do....	178,000	8.5	20,941	.60	106,800
	Potatoes.........do....	2,300,000	65	35,387	.47	1,081,000
	Tobacco......pounds..	91,189,000	565	161,397	.07	6,383,230
	Hay.............tons..	296,818	.98	301,849	10.50	3,116,589
	Cotton..........bales..	13,913	.326	42,667	*.084	537,604
	Total............	....	....	4,042,979	....	33,670,793
North Carolina....	Indian corn....bushels..	27,215,000	10.5	2,596,029	.57	15,512,550
	Wheat...........do....	3,209,000	4.6	696,546	1.00	3,209,000
	Rye..............do....	315,000	4.8	65,551	.86	270,900
	Oats.............do....	6,276,000	9.9	635,064	.45	2,824,200
	Barley...........do....	4,000	14.1	284	.67	2,680
	Buckwheat.......do....	57,000	8.4	6,750	.60	34,200
	Potatoes.........do..	1,273,000	60	21,215	.56	712,880
	Tobacco.......pounds..	31,559,000	420	75,141	.095	2,998,105
	Hay.............tons..	111,182	1.04	106,856	11.00	1,223,002
	Cotton..........bales..	365,762	.341	1,071,658	*.084	14,133,026
	Total............	....	....	5,275,094	....	40,920,543
South Carolina....	Indian corn....bushels..	13,318,000	9.1	1,457,594	.60	7,990,800
	Wheat...........do....	936,000	5.0	187,026	1.08	1,010,880
	Rye..............do....	41,000	4.9	8,285	1.05	43,050
	Oats.............do....	3,440,000	8.7	393,265	.62	2,132,800
	Potatoes.........do....	259,000	63	4,107	.82	212,380
	Hay.............tons..	25,200	1.05	24,000	12.82	323,064
	Cotton..........bales..	498,367	.301	1,655,291	*.083	19,234,481
	Total............	....	....	3,729,568	....	30,947,455
Georgia...........	Indian corn....bushels..	31,197,000	10.8	2,886,277	.60	18,718,200
	Wheat...........do....	1,690,000	4.4	385,954	1.05	1,774,500
	Rye..............do....	146,000	5.4	27,085	1.12	163,520
	Oats.............do....	5,301,000	9.0	589,001	.60	3,180,600
	Barley...........do....	20,000	13.2	1,516	.95	19,000
	Potatoes.........do....	590,000	65	9,083	.95	560,500
	Hay.............tons..	34,980	1.06	33,000	13.00	454,740
	Cotton..........bales..	861,720	.291	2,956,267	*.082	33,210,703
	Total............	....	....	6,888,183	....	58,081,763

* Per pound.

Table showing the product of the cereals, potatoes, tobacco, hay, etc.—Continued.

States.	Products.	Quantity produced in 1886.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Florida	Indian corn....bushels..	4,597,000	10.4	441,074	$0.71	$3,263,870
	Oats..............do...	489,000	9.5	51,467	.63	308,070
	Potatoes..........do....	134,000	67	1,996	1.00	134,000
	Cotton ....bales..	59,332	.219	270,738	*.082	2,286,653
	Total.............	....	....	765,275	....	5,992,593
Alabama	Indian corn....bushels..	28 893,000	12.1	2,393,036	.60	17,335,800
	Wheat............do....	1,529,000	6.9	222,704	1.07	1,636,030
	Rye.............do....	44,000	7.3	6,059	1.20	52,800
	Oats..............do....	4,718,000	11.5	409,807	.62	2,925,160
	Barley ....do....	7,000	11.0	636	.93	6,510
	Potatoes..........do....	614,000	65	9,447	.95	583,300
	Hay ....tons..	31,000	1	31,000	13.50	418,500
	Cotton ....bales..	752,220	.266	2,823,718	*.083	30,467,917
	Total.............	....	....	5,896,407	....	53,426,017
Mississippi	Indian corn... bushels..	25,507,000	13.1	1,946,666	.59	15,049,130
	Wheat ....do....	173,000	4.0	43,062	1.10	190,300
	Rye...............do....	10,000	9.9	1,008	1.25	12,500
	Oats..............do....	3,368,000	9.5	355,001	.63	2,121,840
	Potatoes..........do....	573,000	67	8,556	.87	498,510
	Hay ... .tons..	28,350	1.05	27,000	12.40	351,540
	Cotton ....bales..	935,390	.367	2,548,674	*.083	37,654,110
	Total.............	....	....	4,929,967	....	55,877,930
Louisiana	Indian corn....bushels..	14,640,000	15.6	935,725	.55	8,052,000
	Rye...............do....	10,000	7.8	1,285	.95	9,500
	Oats ....do....	361,000	10.0	36,138	.52	187,720
	Potatoes..........do....	471,000	70	6,728	.92	433,320
	Hay ....tons..	42,882	1.05	40,933	11.50	493,143
	Cotton ....bales..	471,974	.456	1,035,781	*.083	18,999,331
	Total.............	....	....	2,056,590	....	28,175,014
Texas	Indian corn....bushels..	69,213,000	15.7	4,417,678	.56	38,759,280
	Wheat............do....	5,383,000	10.2	529,104	.90	4,844,700
	Rye...............do....	42,000	7.6	5,544	.92	38,640
	Oats..............do....	11,369,000	20.6	552,966	.50	5,684,500
	Barley............do....	108,000	13.5	7,993	.90	97,200
	Potatoes..........do....	569,000	55	10,345	.90	512,100
	Hay ....tons..	92,289	.91	101,562	9.50	876,746
	Cotton ....bales..	1,499,698	.398	3,771,740	*.081	61,102,188
	Total.............	....	....	9,396,932	....	111,915,354
Arkansas	Indian corn....bushels..	42,140,000	20.4	2,069,176	.49	20,648,600
	Wheat............do....	1,815,000	7.8	231,357	.85	1,542,750
	Rye...............do....	34,000	7.9	4,282	.80	27,200
	Oats..............do....	4,749,000	18.0	263,848	.42	1,994,580
	Potatoes..........do....	838,000	67	12,513	.63	527,940
	Tobacco ....pounds..	2,108,000	875	2,409	.075	158,100
	Hay ....tons..	35,047	1.07	32,671	10.80	378,508
	Cotton ....bales..	660,872	.488	1,354,788	*.082	26,662,228
	Total.............	....	....	3,971,044	....	51,939,906
Tennessee	Indian corn....bushels..	73,314,000	20.7	3,533,894	.40	29,325,600
	Wheat............do....	8,024,000	6.7	1,199,400	.78	6,258,720
	Rye ....do....	253,000	7.0	36,137	.70	177,100
	Oats..............do....	7,920,000	12.4	638,699	.32	2,534,400
	Barley............do....	37,000	11.8	3,143	.65	24,050
	Buckwheat.......do....	40,000	7.3	5,515	.60	24,000
	Potatoes..........do....	2,531,000	65	38,937	.42	1,063,020
	Tobacco ....pounds..	31,763,000	640	49,629	.06	1,905,780
	Hay ....tons..	279,487	1.27	220,758	11.25	3,144,229
	Cotton ....bales..	298,133	.352	847,326	*.082	11,881,205
	Total.............	....	....	6,573,438	....	56,338,104

* Per pound.

Table showing the product of the cereals, potatoes, tobacco, hay, etc.—Continued.

States.	Products.	Quantity produced in 1886.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
West Virginia	Indian corn....bushels..	15,194,000	22.8	665,409	$0.42	$6,381,480
	Wheat............do....	3,061,000	10.6	287,788	.80	2,448,800
	Rye ....do....	172,000	9.5	18,[illegible]06	.63	[illegible]08,360
	Oats ....do....	2,803,000	20.1	139,419	.30	840,900
	Barley ....do....	[illegible],000	12.2	573	.5[illegible]	3,500
	Buckwheat ....do....	350,000	8.8	39,724	.59	[illegible]06,500
	Potatoes ....do....	1,952,000	70	27,885	.42	8[illegible]9,840
	Tobacco ....pounds..	2,749,000	625	4,398	.07	192,430
	Hay ....tons..	286,943	.76	378,208	9.33	2,677,178
	Total..............	....	....	1,561,510	....	13,678,988
Kentucky	Indian corn....bushels..	88,758,000	25.2	3,5[illegible]6,150	.34	30,[illegible]77,720
	Wheat............do....	12,405,000	11.2	1,111,728	.72	8,931,600
	Rye...............do....	933,000	10.0	93,347	.56	522,480
	Oats ....do....	10,219,000	21.0	486,630	.32	3,270,080
	Barley ....do....	464,000	25.0	18,564	.52	241,280
	Buckwheat ....do....	13,000	9.0	1,450	.65	8,450
	Potatoes..........do....	3,455,000	67	51,567	.37	1,278,350
	Tobacco ....pounds..	193,915,000	770	251,838	.06	11,634,900
	Hay ....tons..	313,200	.97	322,596	9.80	3,069,360
	Total..............	....	....	5,853,870	....	59,134,220
Ohio	Indian corn....bushels..	96,204,000	32.2	2,987,289	.35	33,671,400
	Wheat............do....	40,362,000	15.0	2,6[illegible]8,468	.74	29,867,880
	Rye...............do....	716,000	13.5	53,000	.56	400,960
	Oats ....do....	31,850,000	32.4	983,606	.28	8,918,000
	Barley ....do....	956,000	27.0	35,418	.56	535,360
	Buckwheat ....do....	146,000	11.5	12,735	.60	87,600
	Potatoes..........do....	11,656,000	78	149,432	.40	4,662,400
	Tobacco ....pounds..	35,333,000	960	36,805	.07	2,473,310
	Hay ....tons..	3,106,257	1.21	2,573,970	9.00	27,956,313
	Total..............	....	....	9,520,723	....	108,573,223
Michigan	Indian corn....bushels..	27,635,000	29.1	948,069	.38	10,501,300
	Wheat............do....	26,572,000	16.0	1,662,721	.73	19,397,560
	Rye...............do....	300,000	12.8	23,463	.56	168,000
	Oats ....do....	18,521,000	29.5	628,116	.34	6,297,140
	Barley ....do....	1,133,000	22.5	50,348	.58	657,140
	Buckwheat ....do....	430,000	13	33,065	.55	236,500
	Potatoes..........do....	11,725,000	80	146,568	.39	4,572,750
	Hay ....tons..	1,642,883	1.16	1,419,311	9.50	15,607,389
	Total..............	....	....	4,911,661	....	57,437,779
Indiana	Indian corn....bushels..	118,795,000	31.9	3,720,681	.32	38,014,400
	Wheat............do....	40,255,000	14.8	2,721,526	.70	28,178,500
	Rye...............do....	441,000	12.0	36,750	.52	229,320
	Oats ....do....	31,798,000	30.7	1,034,923	.27	8,585,460
	Barley ....do....	435,000	21.0	20,735	.57	247,950
	Buckwheat ....do....	92,000	10.5	8,749	.58	53,360
	Potatoes..........do....	6,779,000	72	94,151	.38	2,576,020
	Tobacco ....pounds..	14,880,000	660	22,545	.06	892,800
	Hay ....tons..	3,100,000	1.25	2,480,000	6.50	20,150,000
	Total..............	....	....	10,140,060	....	98,927,810
Illinois	Indian corn....bushels..	209,818,000	24.5	8,559,036	.31	65,043,580
	Wheat............do....	27,562,000	13.7	2,015,400	.69	19,017,780
	Rye...............do....	2,527,000	14.0	180,500	.47	1,187,690
	Oats ....do....	103,649,000	31.8	3,257,180	.26	26,948,740
	Barley ....do....	980,000	23.0	42,615	.52	509,600
	Buckwheat ....do....	172,000	11.3	15,181	.58	99,760
	Potatoes..........do....	9,241,000	67	137,932	.43	3,973,630
	Tobacco ....pounds..	6,158,000	575	10,710	.06	369,480
	Hay ....tons..	4,513,031	1.34	3,372,375	6.40	28,883,398
	Total..............	....	....	17,590,929	....	146,033,658
Wisconsin	Indian corn....bushels..	28,493,000	25.7	1,109,779	.37	10,542,410
	Wheat............do....	14,725,000	11.5	1,281,018	.68	10,013,000
	Rye...............do....	1,986,000	11.5	172,674	.48	953,280
	Oats ....do....	39,656,000	28.4	1,393,349	.28	11,103,680
	Barley ....do....	6,991,000	22.0	317,756	.48	3,355,680
	Buckwheat ....do....	261,000	8.2	31,852	.56	146,160
	Potatoes..........do....	6,974,000	64	108,974	.42	2,929,080
	Tobacco ....pounds..	23,744,000	980	24,229	.10	2,374,400
	Hay ....tons..	1,924,237	1.11	1,732,486	8.60	16,548,438
	Total..............	....	....	6,177,117	....	57,966,128

Table showing the product of the cereals, potatoes, tobacco, hay, etc.—Continued.

States.	Products.	Quantity produced in 1885.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Minnesota	Indian corn....bushels..	19,905,000	29.8	668,380	$0.34	$6,767,700
	Wheat............do....	42,856,000	14.0	3,067,851	.61	26,142,160
	Rye.... ....do....	462,000	14.0	33,031	.44	203,280
	Oats ....do....	40,735,000	34.4	1,184,032	.25	10,183,750
	Barley............do....	8,455,000	23.0	367,601	.42	3,551,100
	Buckwheat ....do....	72,000	11.4	6,343	.60	43,200
	Potatoes..........do....	5,306,000	84	63,161	.37	1,963,220
	Hay ....tons .	600,000	1.25	480,000	4.70	2,820,000
	Total..............	....	....	5,870,399	....	51,674,410
Iowa	Indian corn....bushels..	198,847,000	25.1	7,927,019	.30	59,654,100
	Wheat............do....	32,455,000	12.2	2,657,105	.60	19,473,000
	Rye..............do....	1,700,000	13.6	124,984	.42	714,000
	Oats..............do....	78,454,000	34.1	2,296,752	.23	18,044,420
	Barley............do....	5,045,000	22.5	224,219	.45	2,270,250
	Buckwheat ....do....	234,000	9.5	24,608	.62	145,080
	Potatoes..........do....	7,577,000	54	140,314	.47	3,561,190
	Hay ....tons....	4,137,844	1.13	3,673,875	5.00	20,689,220
	Total..............	....	....	17,070,876	....	124,551,260
Missouri	Indian corn....bushels..	143,709,000	22.2	6,484,600	.31	44,549,790
	Wheat.........do....	21,986,000	13.2	1,662,721	.63	13,851,180
	Rye..............do....	571,000	12.0	47,551	.50	285,500
	Oats ....do....	30,577,000	23.4	1,305,884	.25	7,644,250
	Barley...........do...	180,000	22.5	7,995	.48	86,400
	Buckwheat.......do....	66,000	9.3	7,073	.60	39,600
	Potatoes..........do....	4,109,000	50	82,189	.42	1,725,780
	Tobacco ....pounds..	11,959,000	745	16,053	.07	837,130
	Hay ....tons..	1,464,750	1.09	1,338,750	7.00	10,253,250
	Total..........	....	....	10,952,816	....	79,272,889
Kansas	Indian corn....bushels..	126,712,000	21.8	5,812,615	.27	34,212,240
	Wheat............do....	14,556,000	11.4	1,272,300	.58	8,442,480
	Rye..............do....	2,128,000	11.5	185,000	.41	872,480
	Oats ....do....	25,516,000	26.4	964,930	.25	6,379,000
	Barley.............do....	734,000	21.3	34,472	.36	264,240
	Buckwheat ....do....	20,000	9.8	2,040	.80	16,000
	Potatoes..........do....	5,744,000	58	99,031	.65	3,733,600
	Hay ....tons..	1,848,000	1.40	1,320,000	4.40	8,131,200
	Total..............	....	....	9.690,388	....	62,051,240
Nebraska	Indian corn....bushels..	106,129,000	27.4	3,879,123	.20	21,225,800
	Wheat............do....	17.449,000	11.0	1,579,727	.47	8,201,030
	Rye..............do....	894,000	13.0	68,733	.32	286,080
	Oats ....do....	21,865.000	29.5	742,051	.19	4,154,350
	Barley............do....	3,786,000	22.0	172,088	.31	1,173,660
	Buckwheat ....do....	29,000	8.6	3,356	.60	17,400
	Potatoes..........do....	3,278,000	60	54,630	.40	1,311,200
	Hay ....tons..	1,392,000	1.45	960,000	3.75	5,220,000
	Total..............	....	....	7,459,708	....	41,589,520
California	Indian corn....bushels..	4,262,000	27.2	156,752	.62	2,642,440
	Wheat............do....	36,165,000	11.6	3,104,640	.73	26,400,450
	Rye..............do....	365,000	12.0	30,409	.76	277,400
	Oats ....do....	2,317,000	28.8	80,348	.44	1,019,480
	Barley..... ......do....	16,038,000	22.2	722,450	.65	10,424,700
	Potatoes..........do....	4,753,000	78	60,940	.66	3,136,980
	Hay ....tons..	1,296,234	1.34	967,479	8.15	10,564,307
	Total..............	....	....	5,123,018	....	54,465,757
Oregon	Indian corn....bushels..	178,000	26.7	6,673	.75	133,500
	Wheat............do....	11,133,000	12.6	884,640	.68	7,570,440
	Rye.... ....do....	22,000	16.1	1,365	.75	16,500
	Oats ....do....	5,102,000	25.6	199,199	.42	2,142,840
	Barley ....do....	941,000	27.0	34,845	.52	489,320
	Buckwheat ....do....	9,000	13.4	673	.75	6,750
	Potatoes ....do....	1,037,000	80	12,965	.62	642,940
	Hay .. ..tons..	477,488	1.27	374,850	8.75	4,178,020
	Total..............	....	....	1,515,210	....	15,180,310

Table showing the product of the cereals, potatoes, tobacco, hay, etc.—Continued.

States.	Products.	Quantity produced in 1886.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Nevada	Indian corn....bushels..	22,000	25.7	855	$0.76	$16,720
	Wheat..........do....	72,000	12.9	5,570	.75	54,000
	Oats..........do....	250,000	31.8	7,858	.50	125,000
	Barley..........do....	500,000	20.4	24,497	.68	340,000
	Potatoes..........do....	355,000	75	4,733	.65	230,750
	Hay..........tons.	160,650	1.08	148,500	7.40	1,188,810
	Total..........	....	....	192,013	....	1,955,280
Colorado	Indian corn....bushels..	938,000	31.5	29,778	.50	469,000
	Wheat..........do....	2,419,000	19.8	122,152	.70	1,693,300
	Rye..........do....	42,000	22.0	1,909	.72	30,240
	Oats..........do....	1,591,000	33.0	48,207	.42	668,220
	Barley..........do....	193,000	28.1	6,876	.62	119,660
	Potatoes..........do....	631,000	78	8,096	.57	359,670
	Hay..........tons..	115,000	1.00	115,000	9.80	1,127,000
	Total..........	....	....	332,018	....	4,467,090
Arizona	Indian corn....bushels..	67,000	22.2	3,020	.80	53,600
	Wheat..........do....	297,000	13.5	22,010	.93	276,210
	Barley..........do....	429,000	19.0	22,600	.90	386,100
	Potatoes..........do....	97,000	70	1,385	1.00	97,000
	Hay..........tons..	24,098	.90	26,775	14.75	355,446
	Total..........	....	....	75,790	....	1,168,356
Dakota	Indian corn...bushels..	15,805,000	23.9	662,625	.37	5,847,850
	Wheat..........do....	30,704,000	11.5	2,675,350	.52	15,966,080
	Rye..........do....	67,000	13.0	5,145	.42	28,140
	Oats..........do....	20,651,000	25.0	825,600	.30	6,195,300
	Barley..........do....	1,232,000	22.0	56,000	.38	468,160
	Potatoes..........do....	3,042,000	65	46,800	.58	1,764,360
	Hay..........tons..	385,000	1.40	275,000	4.25	1,636,250
	Total..........	....	....	4,546,520	....	31,906,140
Idaho	Indian corn...bushels..	42,000	21.5	1,950	.67	28,140
	Wheat..........do....	1,039,000	15.9	65,489	.72	748,080
	Rye..........do....	15,000	13.6	1,106	.60	9,000
	Oats..........do....	1,078,000	31.0	34,770	.55	592,900
	Barley..........do....	283,000	22.5	12,576	.48	135,840
	Potatoes..........do....	430,000	105	4,095	.57	245,100
	Hay..........tons..	137,164	1.21	112,995	10.00	1,371,640
	Total..........	....	....	232,981	....	3,130,700
Montana	Indian corn...bushels..	22,000	24.7	890	.65	14,300
	Wheat..........do....	1,509,000	17.0	88,896	.75	1,131,750
	Oats..........do....	1,987,000	35.0	56,774	.55	1,092,850
	Barley..........do....	72,000	22.9	3,144	.46	33,120
	Potatoes..........do....	451,000	106	4,253	.90	405,900
	Hay..........tons..	152,048	1.09	139,650	10.50	1,596,504
	Total..........	....	....	293,607	....	4,274,424
New Mexico	Indian corn....bushels..	973,000	20.0	48,625	.70	681,100
	Wheat..........do....	921,000	11.4	80,566	.70	644,700
	Oats..........do....	528,000	35.0	15,087	.48	253,440
	Barley..........do....	63,000	19.1	3,303	.85	53,550
	Potatoes..........do....	101,000	96	1,050	1.10	111,100
	Hay..........tons..	24,570	.90	27,300	14.50	356,265
	Total..........	....	....	175,931	....	2,100,155
Utah	Indian corn....bushels..	267,000	20.0	13,330	.60	160,200
	Wheat..........do....	1,541,000	15.2	101,704	.62	955,420
	Rye..........do....	32,000	14.1	2,264	.55	17,600
	Oats..........do....	858,000	29.8	28,794	.40	343,200
	Barley..........do....	470,000	23.0	20,417	.49	230,300
	Potatoes..........do....	978,000	85	11,509	.36	352,080
	Hay..........tons..	159,120	1.27	124,848	7.00	1,113,840
	Total..........	....	....	302,866	....	3,172,640

Table showing the product of the cereals, potatoes, tobacco, hay, etc.—Continued.

States.	Products.	Quantity produced in 1886.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Washington	Indian corn....bushels..	88,000	26.1	3,375	$0.75	$66,000
	Wheat............do....	7,560,000	17.0	445,490	.67	5,065,200
	Rye..............do....	21,000	14.9	1,412	.65	13,650
	Oats.............do....	3,126,000	35.4	88,393	.45	1,406,700
	Barley...........do....	872,000	30.0	29,055	.69	601,680
	Potatoes.........do....	1,258,000	115	10,943	.54	679,320
	Hay..............tons..	194,763	1.19	163,894	7.50	1,460,723
	Total	....	....	742,562	....	9,293,273
Wyoming	Wheat..........bushels..	63,000	18.9	3,339	.70	44,100
	Oats.............do....	86,000	31.2	2,756	.55	47,300
	Potatoes.........do....	124,000	96	1,293	.75	93,000
	Hay..............tons..	100,045	1.07	93,500	11.00	1,100,495
	Total	....	....	100,888	....	1,284,895

Summary for each State, showing the product, area, and value of each crop for 1886.

States and Territories.	Corn.			Wheat.		
	Bushels.	Acres.	Value.	Bushels.	Acres.	Value.
Maine	989,000	31,534	$662,630	600,000	41,537	$720,000
New Hampshire	1,364,000	38,578	927,520	169,000	11,154	199,420
Vermont	2,058,000	62,718	1,358,280	410,000	21,567	451,000
Massachusetts	1,922,000	58,821	1,268,520	17,000	1,080	17,000
Rhode Island	408,000	12,946	273,360	....	....	....
Connecticut	1,992,000	58,140	1,254,960	36,000	2,193	35,280
New York	22,426,000	716,572	12,558,560	11,093,000	680,493	9,318,120
New Jersey	9,418,000	346,866	4,709,000	2,260,000	144,528	1,943,600
Pennsylvania	40,545,000	1,438,285	19,656,150	18,255,000	1,435,506	15,151,650
Delaware	3,590,000	216,595	1,507,800	1,177,000	94,790	988,680
Maryland	15,039,000	719,073	6,466,770	7,194,000	586,287	5,899,080
Virginia	32,793,000	2,110,968	14,756,850	5,581,000	683,697	4,520,610
North Carolina	27,215,000	2,596,029	15,512,550	3,209,000	696,546	3,209,000
South Carolina	13,318,000	1,457,594	7,990,800	936,000	187,026	1,010,880
Georgia	31,197,000	2,886,277	18,718,200	1,690,000	385,954	1,774,500
Florida	4,597,000	441,074	3,263,870	....	....	....
Alabama	28,893,000	2,893,036	17,335,800	1,529,000	222,704	1,636,030
Mississippi	25,507,000	1,946,666	15,049,130	173,000	43,062	190,300
Louisiana	14,640,000	935,725	8,052,000	....	....	....
Texas	69,213,000	4,417,678	38,759,280	5,383,000	520,104	4,844,700
Arkansas	42,140,000	2,069,176	20,648,600	1,815,000	231,357	1,542,750
Tennessee	73,314,000	3,523,894	29,325,600	8,024,000	1,199,400	6,258,720
West Virginia	15,194,000	665,409	6,381,480	3,061,000	287,788	2,448,800
Kentucky	88,758,000	3,516,150	30,177,720	12,405,000	1,111,728	8,931,600
Ohio	96,204,000	2,987,289	33,671,400	40,362,000	2,688,468	29,867,880
Michigan	27,635,000	948,059	10,501,300	26,572,000	1,662,721	19,397,560
Indiana	118,795,000	3,720,681	38,014,400	40,255,000	2,721,526	28,178,500
Illinois	209,818,000	8,559,036	65,043,580	27,562,000	2,015,400	19,017,780
Wisconsin	28,493,000	1,109,779	10,542,410	14,725,000	1,281,018	10,013,000
Minnesota	19,905,000	668,380	6,767,700	42,856,000	3,067,851	26,142,160
Iowa	198,847,000	7,927,019	59,654,100	32,455,000	2,657,105	19,473,000
Missouri	143,709,000	6,481,600	44,549,790	21,986,000	1,662,721	13,851,180
Kansas	126,712,000	5,812,615	34,212,240	14,556,000	1,272,300	8,442,480
Nebraska	106,129,000	3,879,123	21,225,800	17,449,000	1,579,727	8,201,030
California	4,262,000	156,752	2,642,440	36,165,000	3,104,640	26,400,450
Oregon	178,000	6,673	133,500	11,133,000	884,640	7,570,440
Nevada	22,000	855	16,720	72,000	5,570	54,000
Colorado	938,000	29,778	469,000	2,419,000	122,152	1,693,300
Arizona	67,000	3,020	53,600	297,000	22,010	276,210
Dakota	15,805,000	662,625	5,847,850	30,704,000	2,675,350	15,966,080
Idaho	42,000	1,950	28,140	1,039,000	65,489	748,080
Montana	22,000	890	14,300	1,509,000	88,896	1,131,750
New Mexico	973,000	48,625	681,100	921,000	80,566	644,700
Utah	267,000	13,330	160,200	1,541,000	101,704	955,420
Washington	88,000	3,375	66,000	7,560,000	445,490	5,065,200
Wyoming	....	....	....	63,000	3,339	44,100
Total	1,665,441,000	75,694,208	610,311,000	457,218,000	36,806,184	314,226,020

Summary for each State, showing product, area, and value for 1886—Continued.

States and Territories.	Rye.			Oats.		
	Bushels.	Acres.	Value.	Bushels.	Acres.	Value.
Maine	29,000	2,385	$25,520	2,701,000	90,490	$1,080,400
New Hampshire	38,000	3,346	33,060	1,081,000	32,766	443,210
Vermont	82,000	6,290	59,860	3,844,000	106,656	1,422,280
Massachusetts	326,000	25,053	228,200	738,000	24,267	324,720
Rhode Island	19,000	1,372	13,680	184,000	6,353	80,960
Connecticut	390,000	29,981	261,300	1,123,000	39,027	471,660
New York	2,890,000	236,875	1,705,100	40,223,000	1,399,097	14,078,050
New Jersey	1,232,000	103,518	702,240	3,734,000	137,455	1,344,240
Pennsylvania	4,545,000	402,179	2,636,100	37,759,000	1,317,063	12,838,060
Delaware	6,000	857	3,600	492,000	21,409	172,200
Maryland	258,000	30,750	154,800	2,470,000	113,322	815,100
Virginia	385,000	51,327	238,700	8,577,000	633,655	2,916,180
North Carolina	315,000	65,551	270,900	6,276,000	635,064	2,824,200
South Carolina	41,000	8,285	43,050	3,440,000	393,265	2,132,800
Georgia	146,000	27,085	163,520	5,301,000	589,001	3,180,600
Florida	....	....	....	489,000	51,467	308,070
Alabama	44,000	6,059	52,800	4,718,000	409,807	2,925,160
Mississippi	10,000	1,008	12,500	3,368,000	355,001	2,121,840
Louisiana	10,000	1,285	9,500	361,000	36,138	187,720
Texas	42,000	5,544	38,640	11,369,000	552,966	5,684,500
Arkansas	34,000	4,282	27,200	4,749,000	263,848	1,994,580
Tennessee	253,000	36,137	177,100	7,920,000	638,699	2,534,400
West Virginia	172,000	18,106	108,360	2,803,000	139,419	840,900
Kentucky	933,000	93,347	522,480	10,219,000	486,630	3,270,080
Ohio	716,000	53,000	400,960	31,850,000	983,606	8,918,000
Michigan	300,000	23,463	168,000	18,521,000	628,116	6,297,140
Indiana	441,000	36,750	229,320	31,798,000	1,034,923	8,585,460
Illinois	2,527,000	180,500	1,187,690	103,649,000	3,257,180	26,948,740
Wisconsin	1,986,000	172,674	953,280	39,656,000	1,398,349	11,103,680
Minnesota	462,000	33,031	203,280	40,735,000	1,184,032	10,183,750
Iowa	1,700,000	124,984	714,000	78,454,000	2,298,752	18,044,420
Missouri	571,000	47,551	285,500	30,577,000	1,305,884	7,644,250
Kansas	2,128,000	185,000	872,480	25,516,000	964,930	6,379,000
Nebraska	894,000	68,733	286,080	21,865,000	742,051	4,154,350
California	365,000	30,409	277,400	2,317,000	80,348	1,019,480
Oregon	22,000	1,365	16,500	5,102,000	199,199	2,142,840
Nevada	....	....	....	250,000	7,858	125,000
Colorado	42,000	1,909	30,240	1,591,000	48,207	668,220
Dakota	67,000	5,145	28,140	20,651,000	825,600	6,195,300
Idaho	15,000	1,106	9,000	1,078,000	34,770	592,900
Montana	....	....	....	1,987,000	56,774	1,092,850
New Mexico	....	....	....	528,000	15,087	253,440
Utah	32,000	2,264	17,600	858,000	28,794	343,200
Washington	21,000	1,412	13,650	3,126,000	88,393	1,406,700
Wyoming	....	....	....	86,000	2,756	47,300
Total	24,489,000	2,129,918	13,181,330	624,134,000	23,658,474	186,137,930

States and Territories.	Barley.			Buckwheat.		
	Bushels.	Acres.	Value.	Bushels.	Acres.	Value.
Maine	252,000	11,206	$163,800	362,000	20,126	$199,100
New Hampshire	89,000	3,857	60,520	92,000	4,784	52,440
Vermont	304,000	11,711	191,520	359,000	17,862	190,270
Massachusetts	75,000	3,248	52,500	92,000	5,281	57,040
Rhode Island	21,000	824	14,910	2,000	127	1,300
Connecticut	14,000	632	8,680	147,000	10,865	82,320
New York	7,712,000	350,544	4,704,320	4,543,000	317,663	2,362,360
New Jersey	....	....	....	453,000	35,376	[illegible]7,270
Pennsylvania	505,000	28,065	303,000	3,513,000	274,445	[illegible]37,020
Delaware	....	....	....	6,000	437	3,420
Maryland	....	....	....	131,000	10,894	81,220
Virginia	21,000	1,151	13,230	178,000	20,911	106,800
North Carolina	4,000	284	2,680	57,000	6,750	34,200
Georgia	20,000	1,516	19,000	....	....	....
Alabama	7,000	636	6,510	....	....	....
Texas	108,000	7,993	97,200	....	....	....
Tennessee	37,000	3,143	24,050	40,000	5,515	24,000
West Virginia	7,000	573	3,500	350,000	39,724	206,500
Kentucky	464,000	18,564	241,280	13,000	1,450	8,450
Ohio	956,000	35,418	535,360	146,000	12,735	87,600
Michigan	1,133,000	50,348	657,140	430,000	33,065	236,500
Indiana	435,000	20,735	247,950	92,000	8,749	53,360

Summary for each State, showing product, area, and value for 1886—Continued.

States and Territories.	Barley.			Buckwheat.		
	Bushels.	Acres.	Value.	Bushels.	Acres.	Value.
Illinois	980,000	42,615	$509,600	172,000	15,181	$99,760
Wisconsin	6,991,000	317,756	3,355,680	261,000	31,852	146,160
Minnesota	8,455,000	367,601	3,551,100	72,000	6,343	43,200
Iowa	5,045,000	224,219	2,270,250	234,000	24,608	145,080
Missouri	180,000	7,995	86,400	66,000	7,073	39,600
Kansas	734,000	34,472	264,240	20,000	2,040	16,000
Nebraska	3,786,000	172,088	1,173,660	29,000	3,356	17,400
California	16,038,000	722,450	10,424,700	....	....	....
Oregon	941,000	34,845	489,320	9,000	673	6,750
Nevada	500,000	24,497	340,000	....	....	....
Colorado	193,000	6,876	119,660	....	....	....
Arizona	429,000	22,600	386,100	....	....	....
Dakota	1,232,000	56,000	468,160	....	....	....
Idaho	283,000	12,576	135,840	....	....	....
Montana	72,000	3,144	33,120	....	....	....
New Mexico	63,000	3,303	53,550	....	....	....
Utah	470,000	20,417	230,300	....	....	....
Washington	872,000	29,055	601,680	....	....	....
Total	59,428,000	2,652,957	31,840,510	11,869,000	917,915	6,465,120

States and Territories.	Potatoes.			Hay.*		
	Bushels.	Acres.	Value.	Tons.	Acres.	Value.
Maine	6,514,000	62,035	$3,582,700	1,103,610	1,286,874	$12,801,876
New Hampshire	2,813,000	27,577	1,322,110	548,256	678,730	6,579,072
Vermont	3,763,000	36,185	1,429,940	965,889	1,023,060	10,045,246
Massachusetts	3,425,000	33,912	2,123,500	661,077	635,893	11,238,309
Rhode Island	649,000	6,493	408,870	78,016	95,778	1,310,669
Connecticut	2,208,000	31,541	1,324,800	540,402	574,649	8,160,070
New York	27,995,000	349,934	11,477,950	5,418,677	,111,023	58,250,778
New Jersey	3,208,000	40,098	1,732,320	517,043	503,664	6,733,259
Pennsylvania	14,606,000	192,183	6,718,760	3,067,201	2,711,186	35,272,812
Delaware	272,000	4,182	136,000	50,025	50,621	612,806
Maryland	1,393,000	20,786	640,780	312,843	289,219	3,597,695
Virginia	2,300,000	35,387	1,081,000	296,818	301,849	3,116,589
North Carolina	1,273,000	21,215	712,880	111,182	106,856	1,223,002
South Carolina	259,000	4,107	212,380	25,200	24,000	323,064
Georgia	590,000	9,083	560,500	34,980	33,000	454,740
Florida	134,000	1,996	134,000	....	....	....
Alabama	614,000	9,447	583,300	31,000	31,000	418,500
Mississippi	573,000	8,556	498,510	28,350	27,000	351,540
Louisiana	471,000	6,728	433,320	42,882	40,933	493,143
Texas	569,000	10,345	512,100	92,289	101,562	876,746
Arkansas	838,000	12,513	527,940	35,017	32,671	378,508
Tennessee	2,531,000	38,937	1,063,020	279,487	220,758	3,144,229
West Virginia	1,952,000	27,885	819,840	286,943	378,208	2,677,178
Kentucky	3,455,000	51,567	1,278,350	313,200	322,596	3,069,360
Ohio	11,656,000	149,432	4,662,400	3,106,257	2,573,970	27,956,313
Michigan	11,725,000	146,568	4,572,750	1,642,883	1,419,311	15,607,389
Indiana	6,779,000	94,151	2,576,020	3,100,000	2,480,000	20,150,000
Illinois	9,241,000	137,932	3,973,630	4,513,031	3,372,375	28,883,398
Wisconsin	6,974,000	108,974	2,929,080	1,9[illegible],237	1,732,486	16,548,438
Minnesota	5,306,000	63,161	1,963,220	660,000	480,000	2,820,000
Iowa	7,577,000	140,314	3,561,190	4,137,844	3,673,875	20,689,220
Missouri	4,109,000	82,180	1,725,780	1,451,750	1,338,750	10,253,250
Kansas	5,744,000	99,031	3,733,600	1,848,000	1,320,000	8,131,200
Nebraska	3,278,000	54,630	1,311,200	1,392,000	960,000	5,220,000
California	4,753,000	60,940	3,136,980	1,296,234	967,479	10,564,307
Oregon	1,037,000	12,965	642,940	477,488	374,850	4,178,020
Nevada	355,000	4,733	230,750	160,650	148,500	1,188,810
Colorado	631,000	8,096	359,670	115,000	115,000	1,127,000
Arizona	97,000	1,385	97,000	24,098	26,775	355,446
Dakota	,042,000	46,800	1,764,360	385,000	275,000	1,636,250
Idaho	430,000	4,095	245,100	137,164	112,995	1,371,640
Montana	45[illegible],000	4,253	405,900	152,048	139,650	1,596,504
New Mexico	101,000	1,050	111,100	24,570	27,300	356,265
Utah	978,000	11,509	352,080	159,120	124,848	1,113,840
Washington	1,258,000	10,943	679,320	194,763	163,894	1,460,723
Wyoming	124,000	1,293	93,000	100,045	93,500	1,100,495
Total	168,051,000	2,287,136	78,441,940	41,796,499	36,501,688	353,437,699

*Including only hay cut on farms, and exclusive of hay cut on public lands and lands of non-residents.

Summary for each State, showing product, area, and value for 1886—Continued.

States and Territories.	Tobacco.			Cotton.		
	Pounds.	Acres.	Value.	Pounds.	Acres.	Value.
Massachusetts	4,231,000	2,594	$592,340			
Connecticut	11,667,000	7,292	1,633,380			
New York	7,583,000	5,833	872,045			
Pennsylvania	34,951,000	28,695	4,124,218			
Maryland	25,238,000	43,892	1,640,470			
Virginia	91,189,000	161,397	6,383,230	6,400,050	42,667	$537,604
North Carolina	31,559,000	75,141	2,998,105	168,250,306	1,071,658	14,133,026
South Carolina				231,740,740	1,655,291	19,234,481
Georgia				405,008,579	2,956,267	33,210,703
Florida				27,886,014	270,738	2,286,653
Alabama				367,083,340	2,823,718	30,407,917
Mississippi				453,663,972	2,548,674	37,654,110
Louisiana				228,907,601	1,035,781	18,999,331
Texas				754,348,000	3,771,740	61,102,188
Arkansas	2,108,000	2,409	158,100	325,149,120	1,354,788	26,662,228
Tennessee	31,763,000	49,629	1,905,780	144,892,746	847,326	11,881,205
West Virginia	2,749,000	4,398	192,430			
Kentucky	193,915,000	251,838	11,634,900			
Ohio	35,333,000	36,805	2,473,310			
Indiana	14,880,000	22,545	892,800			
Illinois	6,158,000	10,710	369,480			
Wisconsin	23,744,000	24,229	2,374,400			
Missouri	11,959,000	16,053	837,130			
All other States and Territories, including Missouri for cotton	3,510,000	6,750	386,100	13,899,765	75,955	1,125,881
Total	532,537,000	750,210	39,468,218	3,127,230,233	18,454,603	257,295,327

Table showing the average yield per acre and price per bushel, pound, or ton of farm products for the year 1886.

States and Territories.	Corn.		Wheat.		Rye.		Oats.		Barley.	
	Bushels.	Price per bushel.	Bushels.	Price per bushel.	Bushels.	Price per bushel.	Bushels.	Price per bushel.	Bushels.	Price per bushel.
Maine	31.4	$0.67	14.4	$1.20	12.2	$0.88	29.8	$0.40	22.5	$0.65
New Hampshire	35.4	.68	15.2	1.18	11.4	.87	33.0	.41	23.1	.68
Vermont	32.8	.66	19.0	1.10	13.0	.73	36.0	.37	26.0	.63
Massachusetts	32.7	.66	15.7	1.00	13.0	.70	30.4	.44	23.1	.70
Rhode Island	31.5	.67			13.8	.72	29.0	.44	25.5	.71
Connecticut	34.3	.63	16.4	.98	13.0	.67	28.8	.42	22.2	.62
New York	31.3	.56	16.3	.84	12.2	.59	28.7	.35	22.0	.61
New Jersey	27.1	.50	15.6	.86	11.9	.57	27.2	.36		
Pennsylvania	28.2	.47	12.7	.83	11.3	.58	28.7	.34	18.0	.60
Delaware	16.6	.42	12.4	.84	7.0	.60	23.0	.35		
Maryland	20.9	.43	12.3	.82	8.4	.60	21.8	.33		
Virginia	15.5	.45	8.2	.81	7.5	.62	13.5	.34	18.2	.63
North Carolina	10.5	.57	4.6	1.00	4.8	.86	9.9	.45	14.1	.67
South Carolina	9.1	.60	5.0	1.08	4.9	1.05	8.7	.62		
Georgia	10.8	.60	4.4	1.05	5.4	1.12	9.0	.60	13.2	.95
Florida	10.4	.71					9.5	.63		
Alabama	12.1	.60	6.9	1.07	7.3	1.20	11.5	.62	11.0	.93
Mississippi	13.1	.59	4.0	1.10	9.9	1.25	9.5	.63		
Louisiana	15.6	.55			7.8	.95	10.0	.52		
Texas	15.7	.56	10.2	.90	7.6	.92	20.6	.50	13.5	.90
Arkansas	20.4	.49	7.8	.85	7.9	.80	18.0	.42		
Tennessee	20.7	.40	6.7	.78	7.0	.70	12.4	.32	11.8	.65
West Virginia	22.8	.42	10.6	.80	9.5	.63	20.1	.30	12.2	.50
Kentucky	25.2	.34	11.2	.72	10.0	.56	21.0	.32	25.0	.52
Ohio	32.2	.35	15.0	.74	13.5	.56	32.4	.28	27.0	.56
Michigan	29.1	.38	16.0	.73	12.8	.56	29.5	.34	22.5	.58
Indiana	31.9	.32	14.8	.70	12.0	.52	30.7	.27	21.0	.57
Illinois	24.5	.31	13.7	.69	14.0	.47	31.8	.26	23.0	.52
Wisconsin	25.7	.37	11.5	.68	11.5	.48	28.4	.28	22.0	.48
Minnesota	29.8	.34	14.0	.61	14.0	.44	34.4	.25	23.0	.42
Iowa	25.1	.30	12.2	.60	13.6	.42	34.1	.23	22.5	.45
Missouri	22.2	.31	13.2	.63	12.0	.50	23.4	.25	22.5	.48
Kansas	21.8	.27	11.4	.58	11.5	.41	26.4	.25	21.8	.36

Table showing the average yield, etc., of farm products for 1886—Continued.

States and Territories.	Corn.		Wheat.		Rye.		Oats.		Barley.	
	Bushels.	Price per bushel.	Bushels.	Price per bushel.	Bushels.	Price per bushel.	Bushels.	Price per bushel.	Bushels.	Price per bushel.
Nebraska	27.4	$0.20	11.0	$0.47	13.0	$0.32	29.5	$0.19	22.0	$0.31
California	27.2	.62	11.6	.73	12.0	.76	28.8	.44	22.2	.65
Oregon	26.7	.75	12.6	.68	16.1	.75	25.6	.42	27.0	.52
Nevada	25.7	.76	12.9	.75			31.8	.50	20.4	.68
Colorado	31.5	.50	19.8	.70	22.0	.72	33.0	.42	28.1	.62
Arizona	22.2	.80	13.5	.93					19.0	.90
Dakota	23.9	.37	11.5	.52	13.0	.42	25.0	.30	22.0	.33
Idaho	21.5	.67	15.9	.72	13.6	.60	31.0	.55	22.5	.43
Montana	24.7	.65	17.0	.75			35.0	.55	22.9	.46
New Mexico	20.0	.70	11.4	.70			35.0	.48	19.1	.85
Utah	20.0	.60	15.2	.62	14.1	.55	29.8	.40	23.0	.49
Washington	26.1	.75	17.0	.67	14.9	.65	35.4	.45	30.0	.69
Wyoming			18.9	.70			31.2	.55		
Average	22.0	.366	12.4	.687	11.5	.538	26.4	.298	22.4	.330

States and Territories.	Buckwheat.		Potatoes.		Hay.		Tobacco.		Cotton.		
	Bushels.	Price per bushel.	Bushels.	Price per bushel.	Tons.	Price per ton.	Pounds.	Price per pound.	Bales.	Pounds.	Price per pound.
Maine	18.0	$0.55	105	$0.55	.86	$11.60					
New Hampshire	19.2	.57	102	.47	.81	12.00					
Vermont	20.1	.53	104	.38	.94	10.40					
Massachusetts	17.4	.62	101	.62	1.04	17.00	1,631	$0.140			
Rhode Island	15.7	.65	100	.63	.81	16.80					
Connecticut	13.5	.56	70	.60	.94	15.10	1,600	.140			
New York	14.3	.52	80	.41	1.06	10.75	1,300	.115			
New Jersey	12.8	.59	80	.54	1.03	13.00					
Pennsylvania	12.8	.54	76	.46	1.13	11.50	1,218	.118			
Delaware	13.7	.57	65	.50	.99	12.25					
Maryland	12.0	.62	67	.46	1.08	11.50	575	.065			
Virginia	8.5	.60	65	.47	.98	10.50	565	.070	.326	150	$0.084
North Carolina	8.4	.60	60	.56	1.04	11.00	420	.095	.341	157	.084
South Carolina			63	.62	1.05	12.82			.301	140	.083
Georgia			65	.65	1.06	13.00			.291	137	.082
Florida			67	1.00					.219	103	.082
Alabama			65	.95	1.00	13.50			.266	130	.083
Mississippi			67	.87	1.05	12.40			.367	178	.083
Louisiana			70	.92	1.05	11.50			.456	221	.083
Texas			55	.90	.91	9.50			.398	200	.081
Arkansas			67	.63	1.07	10.80	875	.075	.488	240	.082
Tennessee	7.3	.60	65	.42	1.27	11.25	640	.060	.352	171	.082
West Virginia	8.8	.59	70	.42	.76	9.33	625	.070			
Kentucky	9.0	.65	67	.37	.97	9.80	770	.060			
Ohio	11.5	.60	78	.40	1.21	9.00	960	.070			
Michigan	13.0	.55	80	.39	1.16	9.50					
Indiana	10.5	.58	72	.38	1.35	6.50	660	.060			
Illinois	11.3	.58	67	.43	1.34	6.40	575	.060			
Wisconsin	8.2	.56	64	.42	1.11	8.60	980	.100			
Minnesota	11.4	.60	84	.37	1.25	4.70					
Iowa	9.5	.62	54	.47	1.13	5.00					
Missouri	9.3	.60	50	.42	1.09	7.00	745	.070			
Kansas	9.8	.80	58	.65	1.40	4.40					
Nebraska	8.6	.60	60	.40	1.45	3.75					
California			78	.66	1.24	8.15					
Oregon	13.4	.75	80	.62	1.27	8.75					
Nevada			75	.65	1.08	7.40					
Colorado			78	.57	1.00	9.80					
Arizona			70	1.00	.90	14.75					
Dakota			65	.58	1.40	4.25	520	.110			
Idaho			105	.57	1.21	10.00					
Montana			106	.90	1.09	10.50					
New Mexico			96	1.10	.90	14.50					
Utah			85	.36	1.27	7.00					
Washington			115	.54	1.19	7.50					
Wyoming			96	.75	1.07	11.00					
Average	12.9	.545	73.5	.467	1.15	8.46	709.9	.074	.349	169.5	.082

Table showing the average cash value per acre of farm products for the year 1886.

States and Territories.	Corn.	Wheat.	Rye.	Oats.	Barley.	Buckwheat.	Potatoes.	Tobacco.	Hay.	Cotton.
Maine	$21.01	$17.33	$10.70	$11.94	$14.62	$9.89	$57.75	....	$9.95	....
New Hampshire	24.04	17.88	9.88	13.53	15.69	10.96	47.94	....	9.69	....
Vermont	21.66	20.91	9.52	13.34	16.35	10.65	39.52	....	9.82	....
Massachusetts	21.57	15.74	9.11	13.38	16.16	10.80	62.62	$228.35	17.67	....
Rhode Island	21.12	....	9.97	12.74	18.09	10.24	62.97	....	13.68	....
Connecticut	21.59	16.09	8.72	12.09	13.73	7.58	42.00	224.00	14.20	....
New York	17.53	13.69	7.20	10.06	13.42	7.44	32.80	149.50	11.40	....
New Jersey	13.58	13.45	6.79	9.78	....	7.56	43.20	....	13.37	....
Pennsylvania	13.25	10.55	6.55	9.75	10.80	6.91	34.96	143.73	13.01	....
Delaware	6.96	10.43	4.20	8.04	....	7.83	32.52	....	12.11	....
Maryland	8.99	10.06	5.03	7.19	....	7.46	30.83	37.38	12.44	....
Virginia	6.99	6.61	4.65	4.60	11.49	5.10	30.55	39.55	10.32	$12.60
North Carolina	5.98	4.61	4.13	4.45	9.44	5.07	33.60	39.90	11.45	13.19
South Carolina	5.48	5.41	5.20	5.42	....	....	51.71	....	13.46	11.62
Georgia	6.49	4.60	6.04	5.40	12.53	....	61.71	....	13.78	11.23
Florida	7.40	....	....	5.99	....	....	67.13	....	....	8.45
Alabama	7.24	7.35	8.71	7.14	10.24	....	61.74	....	13.50	10.79
Mississippi	7.73	4.42	12.40	5.98	....	....	58.26	....	13.02	14.77
Louisiana	8.61	....	7.39	5.19	....	....	64.41	....	12.05	18.34
Texas	8.77	9.16	6.97	10.28	12.16	....	49.50	....	8.63	16.20
Arkansas	9.98	6.67	6.35	7.56	....	....	42.19	65.63	11.59	19.68
Tennessee	8.20	5.22	4.90	3.97	7.65	4.35	27.30	38.40	14.24	14.02
West Virginia	9.59	6.51	5.98	6.03	6.11	5.20	29.40	43.75	7.08	....
Kentucky	8.58	8.03	5.60	6.72	13.00	5.83	24.79	46.20	9.51	....
Ohio	11.27	11.11	7.57	9.07	15.12	6.88	31.20	67.20	10.86	....
Michigan	11.08	11.67	7.16	10.03	13.05	7.15	31.20	....	11.00	....
Indiana	10.22	10.35	6.24	8.30	11.96	6.10	27.36	39.60	8.13	....
Illinois	7.30	9.44	6.58	8.27	11.96	6.57	28.81	34.50	8.56	....
Wisconsin	9.50	7.82	5.52	7.94	10.56	4.59	26.88	98.00	9.55	....
Minnesota	10.13	8.52	6.15	8.60	9.66	6.81	31.08	....	5.88	....
Iowa	7.53	7.33	5.71	7.85	10.13	5.90	25.38	....	5.63	....
Missouri	6.87	8.33	6.00	5.85	10.81	5.60	21.00	52.15	7.66	....
Kansas	5.89	6.64	4.72	6.61	7.67	7.84	37.70		6.16	....
Nebraska	5.47	5.19	4.16	5.60	6.82	5.18	24.00		5.44	....
California	16.86	8.50	9.12	12.69	14.43	....	51.48		10.92	....
Oregon	20.01	8.56	12.09	10.76	14.04	10.03	49.59		11.15	....
Nevada	19.56	9.69	....	15.91	13.88	....	48.75		8.01	....
Colorado	15.75	13.86	15.84	13.86	17.40	....	44.43		9.80	....
Arizona	17.75	12.55	....	....	17.08	....	70.04	57.20	13.28	....
Dakota	8.83	5.97	5.47	7.50	8.36	....	37.70		5.95	....
Idaho	14.43	11.42	8.14	17.05	10.80	....	59.85		12.14	....
Montana	16.07	12.73	....	19.25	10.53	....	95.44		11.43	....
New Mexico	14.01	8.00	....	16.80	16.21	....	105.81		13.05	....
Utah	12.02	9.39	7.77	11.92	11.28	....	30.59		8.92	....
Washington	19.56	11.37	9.67	15.91	20.71	....	62.08		8.91	....
Wyoming	....	13.21	....	17.16	....	....	71.93		11.77	....
Average	8.06	8.54	6.19	7.87	12.00	7.04	34.30	52.61	9.68	13.94

General summary, showing the estimated quantities, number of acres, and aggregate value of the crops of the farm in 1886.

Products.	Quantity produced.	Number of acres.	Value.
Indian corn .... bushels	1,665,441,000	75,694,208	$610,311,000
Wheat .... do	457,218,000	36,806,184	314,226,020
Rye .... do	24,489,000	2,129,918	13,181,330
Oats .... do	624,134,000	23,658,474	186,137,930
Barley .... do	59,428,000	2,652,957	31,840,510
Buckwheat .... do	11,869,000	917,915	6,465,120
Potatoes .... do	168,051,000	2,287,136	78,441,940
Total	3,010,630,000	144,146,792	1,240,603,850
Tobacco .... pounds	532,537,000	750,210	39,468,218
Hay .... tons	41,796,499	36,501,688	353,437,699
Cotton .... bales	6,445,864	18,454,603	257,295,327
Grand total	....	199,853,293	1,890,805,094

Table showing the average yield and cash value per acre, and price per unit of quantity of farm products for the year 1886.

Products.	Average yield per acre.	Average price per unit of quantity.	Average value per acre.	Products.	Average yield per acre.	Average price per unit of quantity.	Average value per acre.
Indian corn..bush..	22.0	$0.366	$8.06	Buckwheat.bush..	12.9	$0.545	$7.04
Wheat........do...	12.4	.687	8.54	Potatoes.....do...	73.5	.467	34.30
Rye...........do...	11.5	.538	6.19	Tobacco......lbs..	709.9	.074	52.61
Oats..........do...	26.4	.298	7.87	Hay.........tons..	1.15	8.46	9.68
Barley........do...	22.4	.536	12.00	Cotton........lbs..	169.5	.082	13.94

FARM ANIMALS.

NUMBERS.

It was stated a year ago that the interest in horse-breeding was unabated; it has been greater still during the past year, resulting in enlargement of numbers and enhancement of the aggregate value. No class of domestic animals has increased in such proportion within the year. The advance averages 5 per cent. and is well distributed through the country, though naturally larger in the States so rapidly developing beyond the Mississippi. It is quite marked on the Pacific coast, a natural result of the rapid increase of population there and development of industrial enterprises generally. Many persons in Ohio and elsewhere are giving up sheep in favor of horses. The tendency in the central States west of the Alleghanies is strong toward larger and heavier horses, suitable for draft purposes, the French breeds predominating in the improvement. In contrast to this there is an influx of bronchos from Texas, and even some are bred by a few farmers, to the deterioration of the stock so far as practiced. These Texas ponies have overrun the cotton States during the past year and are bred in that region to a limited extent. The increase is very noticeable in the ranch regions of the great mountain system. Horses are found to be hardy there, not smothered by crowding together in a storm like sheep, nor drifting aimlessly like cattle, but courageously breasting the blizzards and intelligently seeking subsistence beneath the snow.

There was also a less pronounced advance in the number of mules, estimated at $3\frac{1}{2}$ per cent.

The extension of cattle-growing has been normal, corresponding very nearly with increase of population. Though prices have been low and heavy losses have occurred in some of the ranch districts from cold and storms, often in connection with overcrowding of feeding grounds, there is an abiding faith in the future of the business, grass being the cheapest and most abundant source of beef, yielding perhaps nine-tenths of all that is produced in the country. Corn has a relatively small share in the beef-making in any country. The Northwestern States are giving more and more prominence to cattle, the wheat interest relatively declining in the older settlements.

Milch cows are receiving rather more attention than in recent years in the Eastern and Middle States, and are increasing everywhere with the advance of population, There is some recuperation from the depression felt in cheese-making districts, New York especially, when prices of their products ruled so low.

There has been a further decline in numbers of sheep, amounting to between 2 and 3 per cent., the aggregate number being about 43,500,000. There has also been some change of pastures. Some of the Texas flock-masters have sent considerable numbers to New Mexico. There has been for several years a deportation of sheep from Pennsylvania to the cheaper grasses of the far West.

The decline in swine has been slight, averaging less than 1 per cent., leaving the aggregate over 44,000,000. The ravages of disease in States below the latitude of 40°, where hogs are kept in large numbers, have been severe in many places.

The total number of domestic animals of ranch and farm are thus stated, in comparison with the estimates of last year:

Stock.	1887.	1888.	Increase or decrease.
Horses	12,496,744	13,172,936	+ 676,192
Mules	2,117,141	2,191,727	+ 74,586
Milch cows	14,522,083	14,856,414	+ 334,331
Oxen and other cattle	33,511,750	34,378,363	+ 866,613
Sheep	44,759,314	43,544,755	−1,214,559
Swine	44,612,836	44,346,525	− 266,311

VALUES.

The values of farm animals, those of cattle excepted, have changed very little in the past year. The average for swine has advanced about 10 per cent. The difference in the averages for horses, mules, and sheep are very slight. The rise in value in horses since 1879 has been the most noticeable feature in farm-stock values. The highest prices of the inflation period were reached in 1869, averaging $84.16, declining from that date to the lowest ebb of agricultural depression in 1879 to $52.41. The present price is nearly that of 1874, and does not differ much from the value of 1869 reduced to gold, showing that the price of horses is now relatively high, and furnishing a solid reason for the increase in numbers, and for the frequent expression of correspondents that horses and mules pay the stock-grower better than any other class of animals. There is another good reason for the unyielding prices of horses in a time of general shrinkage of values, viz, the improvement in quality by thoroughbred blood, and especially the increase of weight by the general distribution of French and English draft horses.

Cattle were highest in 1869, $25.12 in 1870, declining until 1879 to $15.39, then rising annually to 1884, the average being $23.52, and declining constantly since, standing now at $17.79. This is higher than at the lowest depression, and at the gold value about the same as at the commencement of the monetary panic of 1873.

From 1879 to 1884 the annual estimates of prices of milch cows and other cattle advanced yearly, and the decline has since been uninterrupted, without exception, for either class of stock. The fall in milch cows has been from $26.08 to $24.65, over 5 per cent.; and in oxen and other cattle from $19.79 to $17.79, a decline of 10 per cent. in the last year.

In sheep, as in other stock, the annual advance was quite steady after 1879 and amounted to 22 per cent. in four years. From 1883 to 1886 the decline was over 25 per cent., or from $2.53 to $1.91. The next year's average was $2.01, and the present average $2.05, or

nearly as much as in the depression of 1879, when prices were the lowest in twenty years.

There has been an advance in the average for swine of all ages from $4.48 to $4.98, or 11 per cent. The annual advance was continuous from 1879 to 1883, then declining to 1886 and slightly advancing again since.

Stock.	1887.	1888.	Increase or decrease.
Horses	$72.15	71.82	−$0.33
Mules	78.91	79.78	+ .87
Milch cows	26.08	24.65	− 1.43
Oxen and other cattle	19.79	17.79	− 2.00
Sheep	2.01	2.05	+ .04
Swine	4.48	4.98	+ .50

An examination of the course of prices, as averaged from local returns, shows a remarkable fluctuation by gradual movement through periods that are sharply defined and limited by obvious causes. It will also give a positive impression of the general accuracy of the averages, so consistent with the controlling conditions in the several States and larger divisions of territory. The record of ten years' prices is as follows:

Years.	Horses.	Mules.	Milch cows.	Other cattle.	Sheep.	Swine.
1879	$52.41	$56.06	$21.73	$15.39	$2.07	$3.18
1880	54.75	61.26	23.27	16.10	2.21	4.28
1881	58.44	69.79	23.95	17.33	2.39	4.70
1882	58.52	71.35	25.89	19.89	2.37	5.98
1883	70.59	79.49	30.21	21.80	2.53	6.75
1884	74.64	84.22	31.37	23.52	2.37	5.57
1885	73.70	82.38	29.70	23.25	2.14	5.02
1886	71.27	79.60	27.40	21.17	1.91	4.25
1887	72.15	78.91	26.08	19.79	2.01	4.48
1888	71.82	79.78	24.65	17.79	2.05	4.98

The comparison of aggregate values with those of last year shows an increased valuation of over $8,000,000, cattle and sheep only showing decrease, while horses, mules, and swine have an increased valuation:

Stock.	1887.	1888.	Increase or decrease.
Horses	$901,685,755	$946,096,154	+$44,410,399
Mules	167,057,538	174,853,563	+ 7,796,025
Milch cows	378,789,589	366,252,173	− 12,537,416
Oxen and other cattle	663,137,926	611,750,520	− 51,387,406
Sheep	89,872,839	89,279,926	− 592,913
Swine	200,043,291	220,811,082	+ 20,767,791
Total	2,400,586,938	2,409,043,418	+ 8,456,480

It is believed that the stock interests of the United States are in a comparatively prosperous condition, with a prospect of advance in prices, of cattle especially. It may not be safe to say that the lowest ebb in the movement of prices has been reached, but there are indications of early advance, if no monetary crisis or business convulsion should intervene, of which there are no immediate indications. An interest that represents $2,400,000,000, and including horses and other animals in cities, not far from $3,000,000,000, is one of the very first agricultural importance, that demands the most intelligent endeavor of farmers to obtain the largest possible annual income from such an investment at the lowest possible cost.

Table showing the estimated number and value of animals on farms January 1, 1888.

States and Territories.	Horses.			Mules.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Maine	94,857	$91.07	$8,638,353			
New Hampshire	49,878	86.18	4,298,244			
Vermont	84,841	84.22	7,145,111			
Massachusetts	65,194	107.61	7,015,576			
Rhode Island	10,055	105.13	1,057,126			
Connecticut	49,381	100.77	4,976,036			
New York	674,018	96.98	65,365,391	5,210	$106.02	$552,366
New Jersey	94,397	105.46	9,955,374	9,501	118.99	1,130,482
Pennsylvania	594,972	93.71	55,757,103	24,143	109.35	2,640,083
Delaware	23,000	94.75	2,179,250	4,102	116.23	476,787
Maryland	130,316	86.00	11,207,590	13,625	108.35	1,476,294
Virginia	243,319	70.89	17,249,636	35,726	87.36	3,121,130
North Carolina	149,708	74.59	11,167,289	89,945	84.13	7,567,056
South Carolina	65,966	90.05	5,940,100	75,451	95.51	7,206,052
Georgia	110,060	83.62	9,203,499	149,654	96.27	14,407,417
Florida	32,743	80.87	2,647,961	12,496	96.02	1,199,895
Alabama	130,853	82.54	10,800,825	137,695	87.01	11,980,525
Mississippi	134,065	71.95	9,645,784	159,548	87.68	13,988,374
Louisiana	119,810	57.15	6,847,597	84,478	88.46	7,472,811
Texas	1,225,803	31.09	38,115,135	193,488	51.85	10,032,254
Arkansas	179,955	59.34	10,678,480	122,457	74.02	9,063,660
Tennessee	300,264	68.92	20,693,234	194,771	73.09	14,236,061
West Virginia	138,281	66.62	9,212,076	6,475	73.70	477,223
Kentucky	390,733	72.30	28,250,002	162,285	71.97	11,680,018
Ohio	723,156	87.30	63,132,673	24,724	89.42	2,210,795
Michigan	458,913	91.80	42,126,410	6,035	103.82	626,572
Indiana	641,716	81.09	52,039,460	54,382	84.32	4,585,456
Illinois	1,069,839	77.25	82,649,687	115,661	83.73	9,684,515
Wisconsin	412,687	78.61	32,441,507	7,930	90.34	716,424
Minnesota	379,489	82.86	31,445,299	10,969	94.30	1,034,415
Iowa	1,003,022	73.81	74,032,082	45,649	86.23	3,936,540
Missouri	782,104	57.59	45,040,996	225,563	66.59	15,019,534
Kansas	634,893	67.34	42,754,975	86,104	83.32	7,173,954
Nebraska	412,980	75.82	31,311,968	41,165	90.40	3,721,363
California	307,004	71.00	21,797,255	38,824	85.03	3,301,389
Oregon	177,842	49.90	8,874,804	3,155	68.38	215,739
Nevada	45,547	51.43	2,342,496	2,154	75.49	162,602
Colorado	127,483	58.34	7,437,086	8,247	92.12	759,697
Arizona	10,267	49.00	503,083	1,882	72.00	135,504
Dakota	247,459	76.21	18,858,156	12,323	97.89	1,206,340
Idaho	102,375	50.00	5,118,750	1,705	65.00	110,825
Montana	187,344	50.96	9,547,985	5,537	63.53	351,746
New Mexico	40,533	34.46	1,396,768	10,803	61.33	662,504
Utah	120,692	40.65	4,906,026	3,686	54.71	201,668
Washington	96,122	61.96	5,955,637	1,243	80.07	99,529
Wyoming	99,000	43.80	4,336,279	2,936	77.64	227,964
Total	13,172,936	71.82	946,096,154	2,191,727	79.78	174,853,563

Table showing the estimated number and value of animals on farms, etc.—Cont'd.

States and Territories.	Milch cows.			Oxen and other cattle.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Maine	167,507	$29.00	$4,857,703	185,160	$27.51	$5,093,108
New Hampshire	99,021	30.50	3,020,141	141,670	29.94	4,241,119
Vermont	225,552	28.70	6,473,342	180,352	28.05	5,059,693
Massachusetts	180,319	34.17	6,161,500	105,023	28.47	2,990,105
Rhode Island	22,883	35.75	818,067	13,154	32.27	424,463
Connecticut	127,153	33.71	4,286,328	109,926	31.24	3,434,104
New York	1,540,053	30.50	46,971,617	851,128	31.92	27,164,603
New Jersey	178,114	35.92	6,397,855	68,541	32.35	2,217,467
Pennsylvania	929,371	23.60	26,580,011	867,059	26.09	22,620,106
Delaware	28,683	30.00	860,490	27,137	28.00	759,835
Maryland	135,021	28.25	3,814,343	138,182	24.18	3,340,798
Virginia	257,793	21.50	5,542,550	423,761	17.37	7,360,725
North Carolina	243,758	16.00	3,900,128	419,383	10.99	4,607,133
South Carolina	146,195	19.00	2,777,705	212,521	12.48	2,651,835
Georgia	337,603	17.00	5,739,251	598,656	11.01	6,588,930
Florida	52,822	16.32	862,055	576,912	8.56	4,941,078
Alabama	296,787	15.40	4,570,520	445,139	9.41	4,187,825
Mississippi	285,904	15.55	4,445,807	428,909	9.48	4,064,000
Louisiana	162,649	16.30	2,651,179	270,816	11.33	3,069,187
Texas	772,716	14.20	10,972,567	6,336,504	9.95	63,077,993
Arkansas	304,404	14.63	4,453,431	469,057	9.81	4,603,415
Tennessee	339,572	19.75	6,706,547	461,239	12.61	5,815,073
West Virginia	171,273	24.07	4,122,541	280,892	18.50	5,196,913
Kentucky	313,953	24.30	7,629,058	529,018	21.24	11,237,676
Ohio	783,481	29.20	22,877,645	967,540	25.60	24,766,690
Michigan	437,303	29.00	12,681,787	511,406	25.16	12,865,948
Indiana	553,961	27.75	15,455,668	894,344	22.44	20,066,941
Illinois	937,476	26.50	24,843,114	1,485,754	22.23	33,029,792
Wisconsin	548,222	23.83	13,064,130	640,752	20.97	13,438,163
Minnesota	433,966	23.75	10,306,693	489,886	20.36	9,974,076
Iowa	1,255,432	23.30	29,251,566	2,095,253	20.35	42,633,795
Missouri	737,259	20.25	14,929,495	1,429,453	18.24	26,077,367
Kansas	640,081	22.41	14,344,215	1,583,915	20.37	32,271,946
Nebraska	357,202	25.50	9,108,651	1,079,646	21.08	22,763,690
California	250,773	33.00	8,275,509	692,267	20.50	14,194,447
Oregon	78,997	29.60	2,338,311	598,218	20.35	12,172,122
Nevada	18,037	35.00	631,295	323,400	18.00	5,819,648
Colorado	63,023	37.21	2,345,086	1,049,353	19.93	20,918,327
Arizona	16,298	37.20	606,286	420,000	18.00	7,560,000
Dakota	223,418	21.67	4,841,468	767,809	21.73	16,687,171
Idaho	26,458	26.67	705,635	424,316	18.75	7,955,925
Montana	31,132	28.40	884,149	934,500	19.21	17,948,007
New Mexico	19,394	23.75	460,608	1,257,597	15.04	18,911,121
Utah	49,878	25.25	1,259,420	435,000	16.76	7,292,733
Washington	65,523	33.30	2,181,916	300,676	23.48	7,060,177
Wyoming	6,994	35.00	244,790	1,230,192	19.11	23,504,663
Indian Territory	....	....	....	626,937	14.50	9,090,587
Total	14,856,414	24.65	366,252,173	34,378,363	17.79	611,750,520

States and Territories.	Sheep.			Hogs.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Maine	547,725	$3.01	$1,645,914	73,188	$9.13	$667,917
New Hampshire	205,023	2.98	610,968	54,399	10.93	594,311
Vermont	393,301	2.85	1,120,279	76,353	9.02	688,385
Massachusetts	62,637	3.30	206,702	65,314	10.30	672,862
Rhode Island	20,852	3.81	79,498	13,261	9.50	125,978
Connecticut	49,199	3.81	187,517	61,776	9.09	561,543
New York	1,564,067	3.46	5,415,582	686,390	8.45	5,803,084
New Jersey	105,276	3.70	389,100	191,818	9.19	1,762,326
Pennsylvania	984,891	2.80	2,756,119	1,027,477	8.03	8,254,748
Delaware	22,294	3.27	72,790	42,654	6.80	290,048
Maryland	160,254	3.35	537,171	281,397	6.24	1,756,621
Virginia	444,741	2.42	1,078,053	811,362	4.34	3,521,313
North Carolina	427,560	1.36	581,054	1,266,438	3.53	4,464,194
South Carolina	107,334	1.72	184,400	550,166	3.92	2,159,072
Georgia	442,274	1.50	664,826	1,534,189	3.17	4,859,083
Florida	92,888	1.96	182,061	307,051	2.05	628,840
Alabama	310,622	1.46	453,135	1,376,148	3.39	4,661,014
Mississippi	247,830	1.57	390,332	1,226,689	3.10	3,801,754
Louisiana	113,965	1.64	186,891	573,821	3.08	1,769,663
Texas	4,523,739	1.52	6,864,774	2,279,082	2.82	6,436,128

Table showing the estimated number and value of animals on farms, etc.—Cont'd

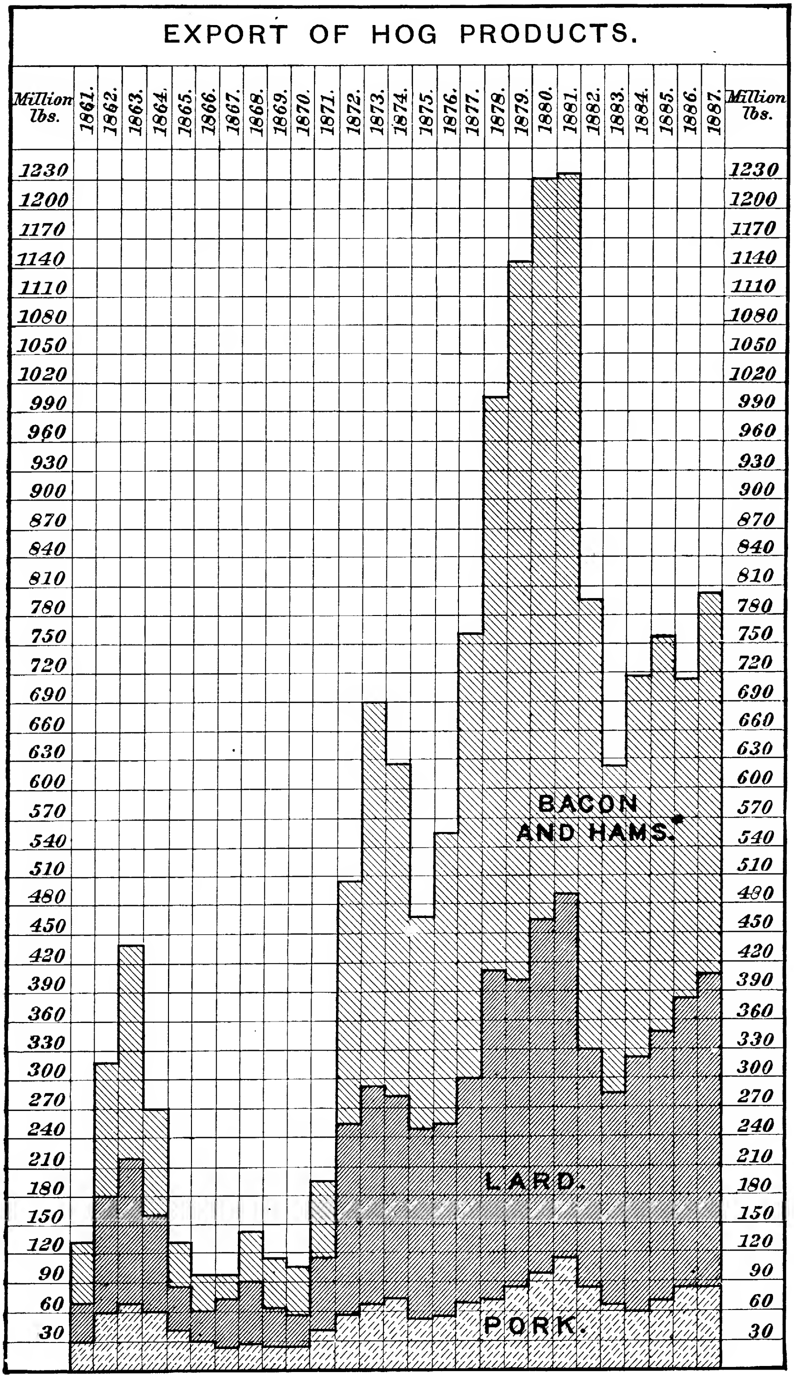
States and Territories.	Sheep.			Hogs.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Arkansas	220,167	$1.41	$310,127	1,538,360	$2.56	$3,938,202
Tennessee	516,594	1.61	832,440	1,853,070	3.66	6,774,825
West Virginia	474,933	2.26	1,073,824	432,778	4.20	1,819,744
Kentucky	797,998	2.43	1,936,741	1,718,173	4.27	7,329,727
Ohio	4,106,622	2.61	10,714,177	2,668,384	5.72	15,261,021
Michigan	2,113,004	2.72	5,743,990	906,255	6.39	5,789,700
Indiana	1,003,068	2.55	2,553,611	2,371,085	5.94	14,082,349
Illinois	814,177	2.49	2,026,894	3,102,945	6.47	20,086,468
Wisconsin	911,662	2.15	1,962,261	1,123,866	6.02	6,76[illegible],798
Minnesota	283,735	2.38	674,698	549,793	5.92	3,254,775
Iowa	408,478	2.41	985,249	4,148,811	6.74	27,969,624
Missouri	1,087,690	1.74	1,894,973	3,798,799	3.96	15,043,246
Kansas	830,139	1.76	1,457,558	2,377,561	5.66	13,457,409
Nebraska	422,112	2.02	852,456	2,334,525	5.72	13,241,813
California	5,462,728	1.88	10,291,779	1,04[illegible],842	4.62	4,836,00[illegible]
Oregon	2,930,123	1.70	4,987,069	220,723	3.01	664,819
Nevada	660,996	1.91	1,259,660	21,087	5.30	111,846
Colorado	1,137,686	1.98	2,257,169	23,419	6.54	153,103
Arizona	658,561	1.75	1,152,482	16,441	5.75	94,536
Dakota	269,019	2.60	700,526	533,970	5.94	3,173,918
Idaho	312,408	2.05	640,436	42,150	6.00	252,900
Montana	1,265,000	2.10	2,658,398	22,289	6.77	150,898
New Mexico	3,623,168	1.09	3,953,239	19,941	5.64	112,466
Utah	1,335,000	1.94	2,594,172	40,118	7.15	286,846
Washington	549,885	1.94	1,068,976	91,054	5.01	455,997
Wyoming	523,340	2.08	1,089,855	2,613	6.64	17,358
Indian Territory	....	....	....	841,500	2.50	2,103,750
Total	43,544,755	2.05	89,279,926	44,346,525	4.98	220,811,082

SWINE PRODUCTS AND EXPORTS.

The prominence of maize in this country has given a remarkable development to the breeding of swine. The estimated numbers at present are near 44,000,000, or about 73 to every 100 of our population. It has sometimes been 80, but the exportation is less than eight or ten years ago, and fat animals are turned off at an earlier age, making more animals slaughtered in proportion to total numbers at a given time. It is probable that the aggregate slaughtered in the Western porking establishments, in commercial packing elsewhere, and by the farmers in all parts of the country amounts to about 29,000,000 per annum. The number slaughtered in the various packing establishments are thus reported by Mr. Charles B. Murray, of Cincinnati:

	1887-'88.	1886-'87.
Western States	11,532,707	12,083,012
Boston	1,185,032	1,016,351
Buffalo, Albany, and Troy	423,950	430,273
New Haven, Providence, etc	560,498	473,901
Other Eastern points	89,077	....
Pacific coast	225,000	395,000
New York, Philadelphia, and Baltimore	2,598,993	2,904,691
	16,615,257	17,303,228

The average exportation of our swine products has been about 15 per cent. of our production for twenty-seven years past. It has averaged about 2,800,000 hogs, or 560,000,000 pounds, if we allow 200


EXPORT OF HOG PRODUCTS.
Million lbs.
1861. 1862. 1863. 1864. 1865. 1866. 1867. 1868. 1869. 1870. 1871. 1872. 1873. 1874. 1875. 1876. 1877. 1878. 1879. 1880. 1881. 1882. 1883. 1884. 1885. 1886. 1887.
1230 1200 1170 1140 1110 1080 1050 1020 990 960 930 900 870 840 810 780 750 720 690 660 630 600 570 540 510 480 450 420 390 360 330 300 270 240 210 180 150 120 90 60 30
BACON AND HAMS.
LARD.
PORK.

pounds of cured product to each, which is probably an approximate figure. The trade is almost as old as the country, and has increased as follows since 1820:

Value by decades of hog products exported.

Decades.	Value.	Decades.	Value.
1821–'30	$15,077,898	1851–'60	$90,439,424
1831–'40	16,821,741	1861–'70	213,955,715
1841–'50	49,902,888	1871–'80	651,364,976

The value of hog products exported (live hogs, bacon and hams, pork and lard), 1881–'87, is $515,701,246, or an average of $73,671,607 per annum, against $65,136,498 per annum in the previous decade.

Diagram F presents a view of the progress of exportation of bacon, hams, pork, and lard, on the basis of quantity, according to the following statement:

Quantities of hog products exported.

Years ended June 30—	Live hogs.		Bacon and hams.		Lard.		Pork.	
	Number.	Price per head.	Pounds.	Price per pound.	Pounds.	Price per pound.	Pounds.	Price per pound.
				Cents.		*Cents.*		*Cents.*
1861	463	$7.06	50,264,267	9.6	47,908,911	9.9	31,297,400	8.3
1882	3,306	7.13	141,212,786	7.3	118,573,307	8.4	61,820,400	6.4
1863	9,467	10.18	218,243,609	8.5	155,336,596	10.1	65,570,300	6.6
1864	9,199	9.45	110,886,446	11.1	97,190,765	11.6	63,519,400	9.2
1865	1,400	9.12	45,990,712	22.9	44,342,295	20.5	41,710,200	16.4
1866	951	16.25	37,588,930	16.7	30,110,451	19.8	30,056,788	15.9
1867	3,577	11.21	25,648,226	12.8	45,608,031	14.5	27,374,877	13.1
1868	1,399	13.19	43,659,064	12.5	64,555,462	14.6	28,690,133	11.4
1869 *	....	....	49,228,165	15.2	41,887,545	17.8	24,439,832	14.2
1870	12,058	15.74	38,968,256	15.7	35,808,530	16.6	24,639,831	13.0
1871	8,770	7.00	71,446,854	11.4	80,037,297	13.2	39,250,750	11.0
1872	56,110	9.77	246,208,143	8.6	199,651,660	10.1	57,169,518	7.2
1873	99,720	7.90	395,381,737	8.9	230,534,207	9.2	64,147,461	7.8
1874	158,581	10.25	347,405,405	9.6	205,527,471	9.4	70,482,379	8.2
1875	61,979	11.38	250,286,549	11.4	166,869,393	13.7	56,152,331	10.1
1876	68,044	9.85	327,730,172	12.1	168,405,839	13.3	54,195,118	10.6
1877	65,107	10.74	460,057,146	10.8	234,741,233	10.9	69,671,894	9.0
1878	29,284	9.13	592,814,351	8.7	342,667,920	8.8	71,889,255	6.8
1879	75,129	9.32	732,249,576	7.0	326,658,686	7.0	84,401,676	5.7
1880	83,434	5.05	759,773,109	6.7	374,979,286	7.4	95,949,780	6.2
1881	77,456	7.39	746,944,545	8.2	378,142,496	9.3	107,928,086	7.7
1882	36,368	14.01	468,026,640	10.0	250,367,740	11.6	80,447,466	9.0
1883	16,129	16.90	340,258,670	11.2	224,718,474	11.8	62,116,302	10.0
1884	46,382	13.53	389,499,368	10.2	265,094,719	9.5	†60,363,313	7.9
1885	55,025	10.58	400,127,119	9.3	283,216,339	8.0	‡71,649,365	7.2
1886	74,187	9.09	419,788,796	7.5	293,728,019	6.9	§87,196,9[illegible]6	5.9
1887	75,383	7.49	419,922,955	7.9	321,533,746	7.1	‖85,869,367	6.6
Total	1,131,908	....	8,029,611,596	....	5,028,196,418	....	1,618,000,188	....

* Animals not separately enumerated in 1869.
† Not including 185,417 pounds of fresh pork.
‡ Not including 424,103 pounds of fresh pork.
§ Not including 70,749 pounds of fresh pork.
‖ Not including 23,930 pounds of fresh pork.

THE WORLD'S WHEAT SURPLUS.

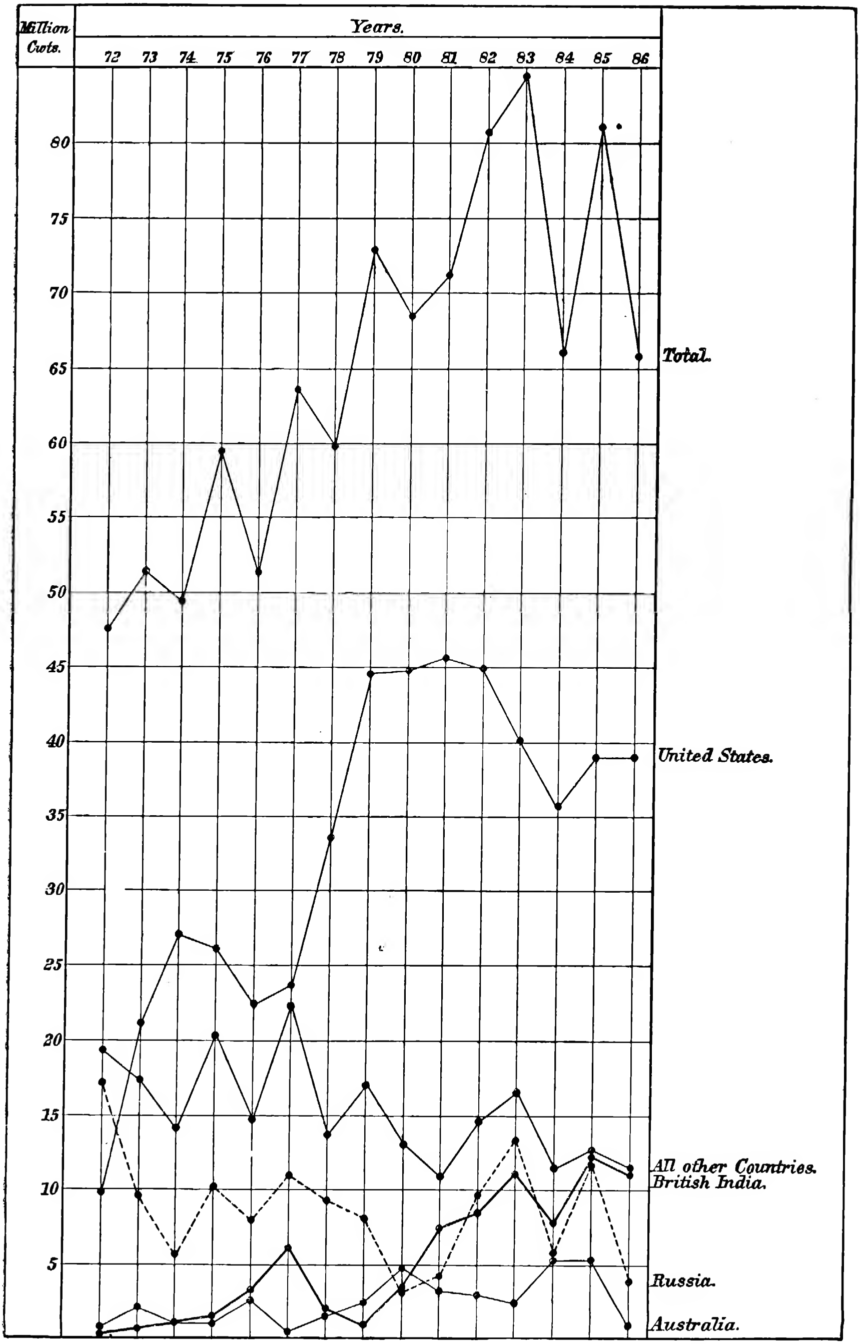
Buyers and sellers of wheat are in continual doubt and difficulty as to the effect of good and bad crops and increase or decrease of area. It has more than once happened that prices have been high when our crop has been large, and low when the product has been small. The cause is no mystery; the law of supply and demand has not been violated, but price has conformed strictly to the supply of the world. Hence the size of our own crop is of no especial consequence except as a factor of the aggregate supply. This country produces more than one-fifth of the wheat of the world; Europe more than half, and the entire deficiency of the world, not mentioning unconsidered trifles which commerce carries to a few wheat-eating people in distant ports, is found in western Europe, mostly in Great Britain.

An analysis of the official statistics of Great Britain shows where needed wheat has been obtained, and in what proportion each country is a factor. It will perhaps surprise many to learn that for this period, from 1872 to 1884, inclusive, the United States has furnished in grain and flour 51.1 per cent., more than one-half of the whole, and for the sixteenth year, 1887, the proportion has increased to 62.7 per cent. Russia in fifteen years averaged 13.6 per cent. of the whole, and for the year 1887 only 7.1 per cent. India contributed an average of 7.9 per cent., and for the year closing 10.9 per cent., which is the smallest percentage in the last five years, and a very sharp decline from the previous year in absolute quantity. Australasia is quite fluctuating in its contribution, averaging 3.9 per cent. for fifteen years and 1.7 per cent. the sixteenth, sending less than a million hundredweights one year and five millions another season. These three competitors of the United States have together furnished only 25.4 per cent., less than half as much, during fifteen years, and a much smaller proportion the past year.

The following table shows the proportion sent by the four main sources of supply, the remainder, though aggregating nearly as much as Russia, India, and Australasia together, gathered from many countries of Europe, Asia, Africa, and the Americas:

Years.	United States.	British India.	Russia.	Australasia.	All other countries.	Total.
	Cwt.	*Cwt.*	*Cwt.*	*Cwt.*	*Cwt.*	*Cwt.*
1872	9,634,349	161,915	17,938,977	556,180	19,321,475	47,612,896
1873	21,775,110	741,350	9,693,997	2,091,504	17,329,236	51,631,197
1874	27,206,052	1,074,390	5,798,976	1,156,599	14,086,676	49,322,693
1875	26,372,151	1,334,374	10,157,847	1,265,747	20,416,502	59,546,621
1876	22,223,403	3,296,575	8,911,788	2,842,200	14,630,467	51,904,433
1877	23,594,005	6,106,079	11,003,917	451,102	22,336,326	63,491,429
1878	33,588,160	1,820,881	9,150,151	1,561,006	13,571,385	59,691,583
1879	44,619,619	889,531	8,117,485	2,294,653	17,080,822	73,002,110
1880	44,783,100	3,230,144	2,963,759	4,613,353	12,869,458	68,459,814
1881	45,699,956	7,338,751	4,099,972	3,314,540	10,891,44	71,344,659
1882	44,888,181	8,463,716	9,679,941	3,086,288	14,444,377	80,562,503
1883	40,216,835	11,248,988	13,448,368	2,790,152	16,845,928	84,550,271
1884	35,561,652	7,980,981	5,520,450	5,369,358	11,742,841	66,175,282
1885	38,937,731	12,175,260	12,082,391	5,443,588	12,650,948	81,289,918
1886	38,930,145	11,027,143	3,748,925	829,564	11,261,979	65,797,756
Total	498,030,449	76,890,078	132,316,944	37,665,834	229,479,860	974,383,165
Percentages	51.1	7.9	13.6	3.9	23.5	

BRITISH WHEAT SUPPLY OF FIFTEEN YEARS.



The actual quantity imported by Great Britain averages 121,256,572 bushels per annum for fifteen years (counting bushels at 60 pounds), of which the United States has contributed 929,656,838 bushels, or an average of 61,977,122 bushels annually. Stated in bushels, for other countries, the record is:

Countries.	In fifteen years.	Average.
	Bushels.	*Bushels.*
United States	929,656,838	61,977,122
Russia	246,991,629	16,466,109
India	143,528,146	9,568,543
Australasia	70,309,557	4,687,304
Other countries	428,362,405	28,557,494
Total	1,818,848,575	121,256,572

Diagram G shows the total importation into Great Britain, and the relative proportions supplied by the United States, Russia, India, and Australasia during fifteen years.

The share contributed by Russia has been very variable. It was largest in the first year of the fifteen, and ranges from 3,000,000 to 18,000,000 hundredweight. It has recently been less than in former years.

The increased receipts from India since 1882 have given false impressions of the importance of competition from that quarter. The commercial press has become especially excited over the temporary movement which has already been retarded for lack of export wheat. Three or four years ago there was a small increase of acreage, a million or two above the normal 26,000,000 which had been seeded from time immemorial, which has already been partly given up.

There is small prospect of increased exportation for India except by slow degrees, and subject to frequent lapses by reason of poor crop years. The natives still work for a few cents per day, plow with a stick, thrash in the primitive fashion, and market dirt and seeds of weeds with the grain. The habits and prejudices of centuries still cling to them. Their food is still rice and millets, and few of them know the taste of wheat. In numbers four times as many as the people of this country, they have less than 27,000,000 acres in wheat, which is eaten mainly by Europeans in India. Under present conditions there is little land to spare for extension of wheat culture. It could be done by infusing occidental progressiveness into beings steeped in oriental inertia from time immemorial, teaching them a new agriculture, training them in the use of modern implements, and doubling the products of agricultural cultivation, thus releasing lands for new industries. These changes, if sudden, would be miracles. There is scarcely a people on the face of the globe less likely to change their industrial status suddenly.

The official estimates of India show that in Bombay there was some increase in 1884, and in Central India and Hyderabad in the native states. Not only has this tendency been arrested, but a decline has occurred in the heart of the Northwestern Provinces and Oude and in Punjab. The following statement shows the movement of wheat-growing in India:

	1878–'79.	1883–'84.	1884–'85.	1885–'86.	1886–'87.
PROVINCES.					
Bengal	1,000,0 0	*850,000	850,000	850,000	1,009,335
North western Provinces and Oude	6,659,343	5,186,000	5,298,000	5,240,000	4,962,942
Punjab	6,909,702	7,209,000	7,382,000	6,970,600	5,943,400
Central Provinces	3,143,302	3,736,000	3,700,000	3,903,000	4,297,949
Berar	617,256	970,000	819,000	809,000	933,938
Bombay (including Baroda)	1,482,804	2,245,000	†3,158,000	†2,970,000	†2,860,454
Total	19,812,407	20,196,000	21,207,000	20,742,600	20,608,018
NATIVE STATES.					
Rajputana	....	2,500,000	2,250,000	1,500,000	1,562,309
Central India	....	2,500,000	3,500,000	3,500,000	3,500,000
Hyderabad	....	750,000	750,000	1,144,000	1,156,229
Mysore	....	20,000	21,740	20,000	8,928
Kashmir	....	500,000	500,000	500,000	500,000
Total	6,000,000	‡6,270,000	§7,021,740	6,664,000	6,727,466
Grand total	25,812,407	†26,466,000	28,228,740	27,394,000	26,735,484

*Supposed normal area.
†Including native states (besides Baroda) under control of the government of Bombay, estimated in 1885–'86 at 608,254 acres for three years past.
‡Given in 1884–'85 as the supposed normal area.
§These items foot up 200,000 acres more than the totals given in the official document.

As to the production, Dr. Forbes Watson, in 1879, in an elaborate official quarto, estimated the annual product at 40,000,000 quarters, or 320,000,000 bushels, and including the native states, 380,000,000 bushels in India. If there was ever so large a product in India, there certainly has not been in recent years. The official estimates of four years are as follows:

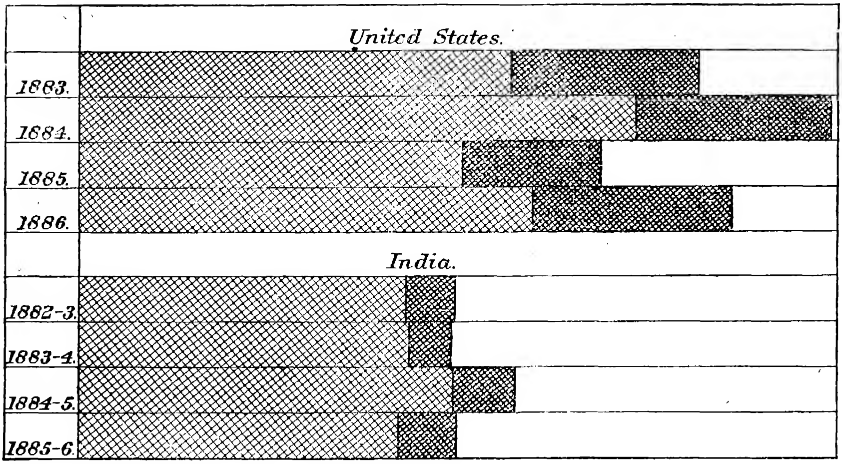
	Bushels.
1883–'84	251,690,880
1884–'85	299,155,584
1885–'86	258,317,632
1886–'87	238,585,947
Average	261,937,511

The ordinary yield is little more than 9 bushels per acre; 11 bushels per acre is an extreme rate of yield. The average is about three-fourths of our average rate of yield. Comparing the average annual exports of India for ten years with those of the United States, the following statement is made:

	Bushels.	Per cent.
India	24,521,050	9.0
United States	136,666,032	31.3

Our exports are nearly six times as much as those of India, and almost a third of the total product, while India exported only one-eleventh of her production.

COMPARATIVE PRODUCTION AND EXPORTATION.



The exports from India, as given officially for two decades, are as follows:

Years.	Bushels.	Value.	Value per bushel.	Years.	Bushels.	Value.	Value per bushel.
1868	558,852	$493,015	$0.88	1878	11,896,580	$13,985,177	$1.17
1869	514,231	480,616	.93	1879	1,972,544	2,531,252	1.28
1870	145,988	160,225	1.10	1880	4,109,495	5,471,245	1.33
1871	463,908	505,303	1.09	1881	13,896,167	15,952,105	1.15
1872	1,189,251	1,146,766	.96	1882	37,148,543	43,163,723	1.16
1873	735,485	816,063	1.11	1883	26,495,024	29,631,213	1.12
1874	3,277, 81	4,027,545	1.23	1884	39,202,636	43,291,464	1.10
1875	2,004,156	2,391,646	1.19	1885	29,588,311	30,736,902	1.04
1876	4,686,767	4,410,660	.94	1886	39,328,658	38,957,943	.99
1877	10,428,327	9,526,855	.91	1887	41,588,250	41,977,826	*1.01

*This price is the average for the greater part of the year.

The product of the year ended March 31, 1888, may be a little larger than the previous crop, and may possibly prove to be nearly an average crop.

In South America, the Argentine Republic especially, there is an immense area of land suited to wheat culture. It has been a pastoral country, but European immigration is extending arable culture rapidly. The total area in crops was estimated in the spring of 1887 at 5,262,600 acres, an increase of 23 per cent. in three years. Of this, 2,112,600 were in wheat, producing nearly 20,000,000 bushels, of which about half was available for exportation. Should immigration continue, wheat culture will be rapidly extended, and much the larger portion of the product be exported. It would be far easier to supply the entire European deficiency from South America than from India, if it is to be accomplished by European stimulation of the industry. Chili has a small but steady export trade in wheat.

Australasia is now less prominent in this trade than South America.

SURPLUS PRODUCTS OF AMERICAN AGRICULTURE.

There is no country in the world which furnishes an agricultural surplus at all comparable with that of the United States, and none with a surplus in such proportion to its production. In fact, it is rarely the case that a country has any excess above consumption, except in occasional crops or in years of exceptional abundance. That this country should regularly have a surplus of not less than 10 per cent. of the value of all its immense production, after supplying with profuse liberality the wants of 60,000,000 people, is a matter of surprise and wonder elsewhere. It is more noticeable from the large proportion of certain crops that can be exported, notably cotton and tobacco, amounting to two-thirds of the former and half of the latter. Of provisions, pork products have always been abundant for export, and cheese has been largely exported since the rise of associated cheese-making. The beef exportation was not known a dozen years ago, except in the salted forms. These articles constitute nearly all of our agricultural surplus; other items are numerous, but small in detail and in the aggregate.

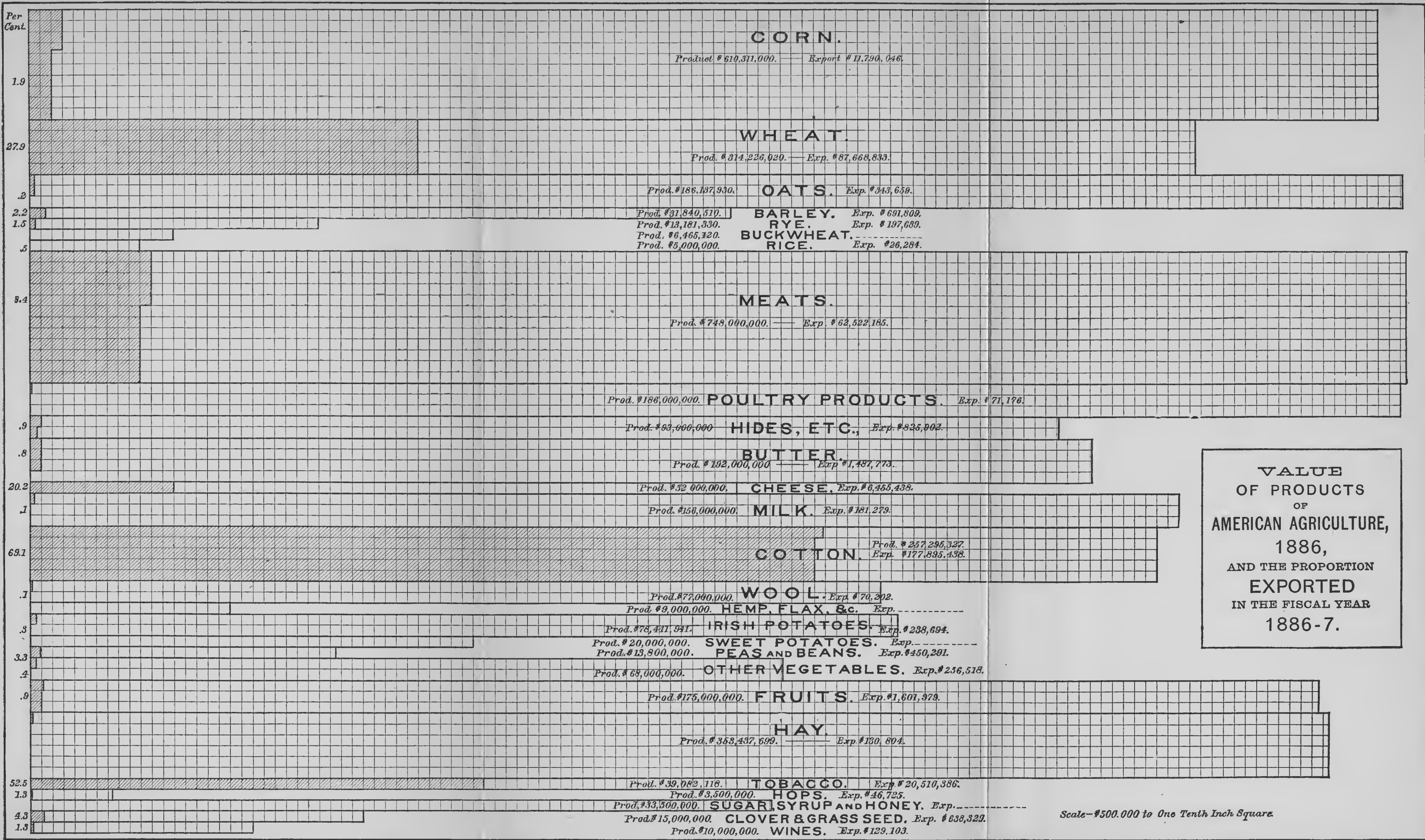
The agricultural production of the country includes all that is grown in the temperate climates of the world, and a great variety of subtropical products. The variety is increasing as the Department of Agriculture and enterprising individuals introduce new plants and animals as foundations of new rural industries.

The census has never attempted to enumerate and value all these forms of production. This Department has attempted to indicate approximately the quantities or values of such products, but has not exhausted the investigation. The following table is given as a tentative estimate of farm values of the products and exports of agriculture:

Value of products of American agriculture in 1886, *and of the proportion exported in the fiscal year* 1886–'87.

Products.	Production (farm value).	Exportation (farm value).	Per cent.
Breadstuffs:			
Corn	$610,211,000	$11,790,046	1.9
Wheat	314,226,020	87,668,833	27.9
Oats	186,137,930	343,659	.2
Barley	31,840,510	691,809	2.2
Rye	13,181,330	197,087	1.5
Buckwheat	6,465,120		
Rice	5,000,000	26,284	.5
Total	1,167,161,910	100,718,318	8.6
Meats	748,000,000	62,522,185	8.4
Poultry products	186,000,000	71,176	
Hides, hair, etc	93,000,000	825,902	.9
Dairy products:			
Butter	192,000,000	1,487,773	.8
Cheese	32,000,000	6,455,438	20.2
Milk	156,000,000	181,279	.1
Total	380,000,000	8,124,490	2.1
Textile fibers:			
Cotton	257,295,327	177,895,501	69.1
Wool	77,000,000	70,202	.1
Hemp, flax, etc	9,000,000		
Total	343,295,327	177,965,703	51.8

AGRICULTURAL PRODUCTION AND EXPORTS OF THE UNITED STATES.



Value of products of American agriculture in 1886, *etc.*—**Continued.**

Products.	Production (farm value).	Exportation (farm value).	Per cent.
Vegetables:			
Irish potatoes	$78,441,940	$238,694	.3
Sweet potatoes	20,000,000		
Peas and beans	13,800,000	450,291	3.3
Market gardens	68,000,000	256,518	.4
Fruits	175,000,000	1,601,979	.9
Hay	353,437,699	130,804	
Tobacco	39,082,118	2,510,386	52.5
Hops	3,500,000	46,725	1.3
Sugar and sirup, including honey	33,500,000		
Clover and grass seed	15,000,000	638,329	4.3
Wines	10,000,000	129,103	1.3
Grand totals	3,727,218,994	374,230,603	10.1

In the statement of value of agricultural products is included meats, hides, milk, and fruit consumed, in addition to those enumerated in the census. There are minor products, such as medicinal herbs, peppermint, teasels, and many others of small value, which are not included. The corn fodder and straw of cereals, and various kinds of green forage, ensilage, etc., are not included, because a large part of it goes into the production of meat, dairy products, wool, etc., while a considerable part of it goes to the sustenance of work-animals and the betterment of stock, and is fairly entitled on that account to be considered as a part of the unduplicated products of agriculture.

On the other hand, about half of the corn is duplicated in other enumerated products. The other cereals do not enter into meat and milk products. Making all necessary allowance for unenumerated products on one side and duplications on the other, I assume that the net agricultural production of the country amounted in 1886 to $3,600,000,000 in round numbers, and possibly to the full aggregate of the table above. These values are the values on the farm or of primary markets. They represent what the production is worth to the farmers. The value of exports, which are those made from the crops of 1886, are not those of the sea-ports, but of the farm. It is manifestly unfair to compare the exported products with the whole production on a different basis of value for each. In reducing to farm value the export values of wheat and corn, which come mainly from beyond the Mississippi, the average farm values of the district of production are taken.

It appears that the proportion of all agricultural products exported is about 10 per cent., or exclusive of cotton and tobacco, 5 per cent.

The tables below show an aggregate value of agricultural exports of $520,820,758, as reckoned in sea-port values, including all the cost of transportation and other commercial expenses. The farm value of those products would fall below a total of $400,000,000. On the other hand, the imports of agricultural products, mostly food products, amount to $287,542,266, plus the cost of ocean transportation and commercial charges and profits, and whatever of undervaluation may exist in the import prices. The real value is therefore not less than $350,000,000 at least, leaving possibly an actual balance of $50,000,000 in favor of net agricultural exports after the payment for

imports of agricultural productions. This is a handsome annual balance, but not the munificent sum with which our net surplus of agricultural production is credited by the exaggerations of the patriotic orator or editor.

Exports of the products of domestic agriculture, 1886 and 1887.

Articles.	1886.		1887.	
	Quantities.	Value.	Quantities.	Value.
Animals, living:				
Cattle ... number	119,065	$10,958,954	106,459	$9,172,136
Hogs ... do	74,187	674,297	75,383	564,753
Horses ... do	1,616	348,323	1,611	351,607
Mules ... do	1,191	148,711	1,754	214,738
Sheep ... do	177,594	329,844	121,701	254,725
All other, and foals		58,531		40,403
Animal matter:				
Bones, hoofs, horns and horn-tips, strips, and waste		127,735		162,958
Casings for sausages		700,382		538,236
Eggs ... dozen	252,202	46,105	372,772	60,686
Glue ... pounds	297,653	42,137	275,362	39,773
Grease, grease scraps, and all soap stock		921,337		849,908
Hair, and manufactures of		407,672		335,548
Hides and skins, other than furs		873,925		765,655
Honey		44,735		67,154
Oils:				
Lard ... gallons	973,229	500,011	975,163	519,274
Other animal ... do	360,223	218,643	570,376	291,396
Provisions, comprising meat and dairy products:				
Meat products—				
Beef products—				
Beef, canned		3,436,453	43,050,588	3,462,982
Beef, fresh ... pounds	99,423,362	9,291,011	83,560,874	7,228,412
Beef, salted or pickled ... do	58,903,370	3,544,379	36,287,188	1,972,246
Beef, other cured ... do	824,955	89,593	192,191	17,942
Tallow ... do	40,919,951	2,144,499	63,278,403	2,836,300
Mutton ... do	1,059,435	93,082	371,572	18,397
Oleomargarine—				
Imitation butter ... do	928,053	93,363	834,574	88,848
The oil ... do	27,729,885	2,954,954	45,712,985	4,676,131
Pork products—				
Bacon ... do	369,423,351	26,899,111	364,417,744	27,338,943
Hams ... do	50,365,445	4,741,100	55,505,211	5,975,727
Pork, fresh ... do	70,749	3,985	23,930	1,233
Pork, salted or cured ... do	87,196,966	5,119,426	85,869,367	5,640,094
Lard ... do	293,728,019	20,361,786	321,533,746	22,703,921
Poultry and game		28,484		28,284
All other meat products		947,524		956,534
Dairy products—				
Butter ... do	18,953,990	2,958,457	12,531,171	1,983,698
Cheese ... do	91,877,235	7,662,145	81,255,994	7,594,633
Milk		255,864		258,9[illegible]1
Wax, bees' ... do	136,179	36,626	90,350	24,997
Wool, raw ... do	2,138,080	476,274	257,940	78,00[illegible]
Total value of animals and animal matter		107,539,458		107,115,245
Bread and breadstuffs:				
Barley ... bushels	252,183	166,330	1,305,300	853,405
Bread and biscuit ... pounds	16,778,850	725,476	15,060,061	659,924
Indian corn ... bushels	63,655,433	31,730,922	40,307,252	19,347,361
Indian-corn meal ... barrels	293,546	858,370	265,333	705,343
Oats ... bushels	5,672,694	1,944,772	440,283	179,634
Oatmeal ... pounds	29,495,008	755,973	16,818,330	456,023
Rye ... bushels	196,725	133,105	357,256	216,190
Rye flour ... barrels	3,329	12,733	3,341	11,781
Wheat ... bushels	57,759,209	50,262,715	101,971,949	90,716,481
Wheat flour ... barrels	8,179,241	38,442,955	11,518,449	51,950,028
All other breadstuffs and preparations of, used as food		813,207		672,384
Total value of bread and breadstuffs		125,846,558		165,768,662
Cotton and cotton-seed oil:				
Cotton—				
Sea island ... pounds	4,613,675	1,176,025	8,021,497	1,798,272
Other unmanufactured ... do	2,053,423,769	203,909,617	2,161,435,833	204,423,785
Cotton-seed oil ... gallons	6,240,139	2,115,974	4,067,138	1,578,935
Total value of cotton and cotton-seed oil		207,201,616		207,800,992

Exports of the products of domestic agriculture, 1886 and 1887—Continued.

Articles.	1886. Quantities.	1886. Value.	1887. Quantities.	1887. Value.
Miscellaneous:				
Broom corn		$134,185		$170,534
Fruits:				
Apples, dried ... pounds	10,473,183	548,434	8,130,396	413,363
Apples, green or ripe ... barrels	744,539	1,810,606	591,868	1,382,872
Fruits, preserved:				
Canned		580,422		506,794
Other		28,339		29,489
All other green, ripe, or dried		340,507		337,447
Hay ... tons	13,390	237,902	13,873	218,006
Hops ... pounds	13,665,661	1,714,488	260,721	54,970
Oil cake and oil-cake meal ... do	585,947,181	7,053,714	622,295,233	7,309,691
Oils:				
Linseed ... gallons	78,885	41,963	119,840	57,136
Other vegetable		43,519		65,689
Rice ... pounds	256,311	14,241	644,384	29,204
Seeds:				
Clover ... do	2,652,438	264,882	7,932,390	630,850
Cotton ... do	11,793,411	112,782	11,232,141	121,441
Timothy ... do	4,023,937	175,754	6,500,004	281,048
All other		1,396,572		874,070
Tobacco:				
Leaf ... pounds	281,737,120	26,926,544	293,666,995	25,637,983
Stems and trimmings ... do	11,036,770	231,913	11,253,128	310,294
Vegetables:				
Onions ... bushels	68,811	75,838	71,689	73,515
Peas and beans ... do	408,318	570,153	387,222	562,864
Potatoes ... bushels	494,948	346,864	434,864	318,259
Vegetables, canned		190,339		228,567
All other, including pickles		134,293		125,448
Wine:				
In bottles ... dozen	6,051	24,813	4,426	23,499
Not in bottles ... gallons	119,085	93,297	282,607	191,672
All other agricultural products		154,132		181,154
Total value of miscellaneous products		*43,246,496		*40,135,859
RECAPITULATION.				
Total value of animals and animal matter		107,539,458		107,115,245
Total value of bread and breadstuffs		125,846,558		165,768,662
Total value of cotton and cotton-seed oil		207,201,616		207,800,992
Total value of miscellaneous products		43,246,496		40,135,859
Total agricultural exports		483,834,128		†520,820,758
Total exports		665,964,529		703,022,923
Per cent. of agricultural matter		73		74

*In this compilation of agricultural exports sugar and molasses are not included, because they are mainly re-exports of foreign sugar.

† This total of agricultural exports differs for 1887 from that given by the Bureau of Statistics of the Treasury Department ($523,073,798), they having included "ginsing and roots, herbs, and barks not otherwise specified," ($834,848), more properly forest products, and "glucose or grape sugar," ($118,620), properly and always before classed as a manufactured product.

Imports of agricultural products, 1886 and 1887.

Articles.	1886.	1887.
Sugar and molasses:		
Sugar	$80,773,744	$78,411,224
Molasses	5,595,670	5,355,475
Total sugar and molasses	86,369,414	83,766,699
Tea, coffee, and cocoa:		
Tea	16,020,383	16,771,803
Coffee	42,672,937	56,347,600
Cocoa	1,793,398	1,670,013
Total tea, coffee, and cocoa	60,486,718	74,789,414

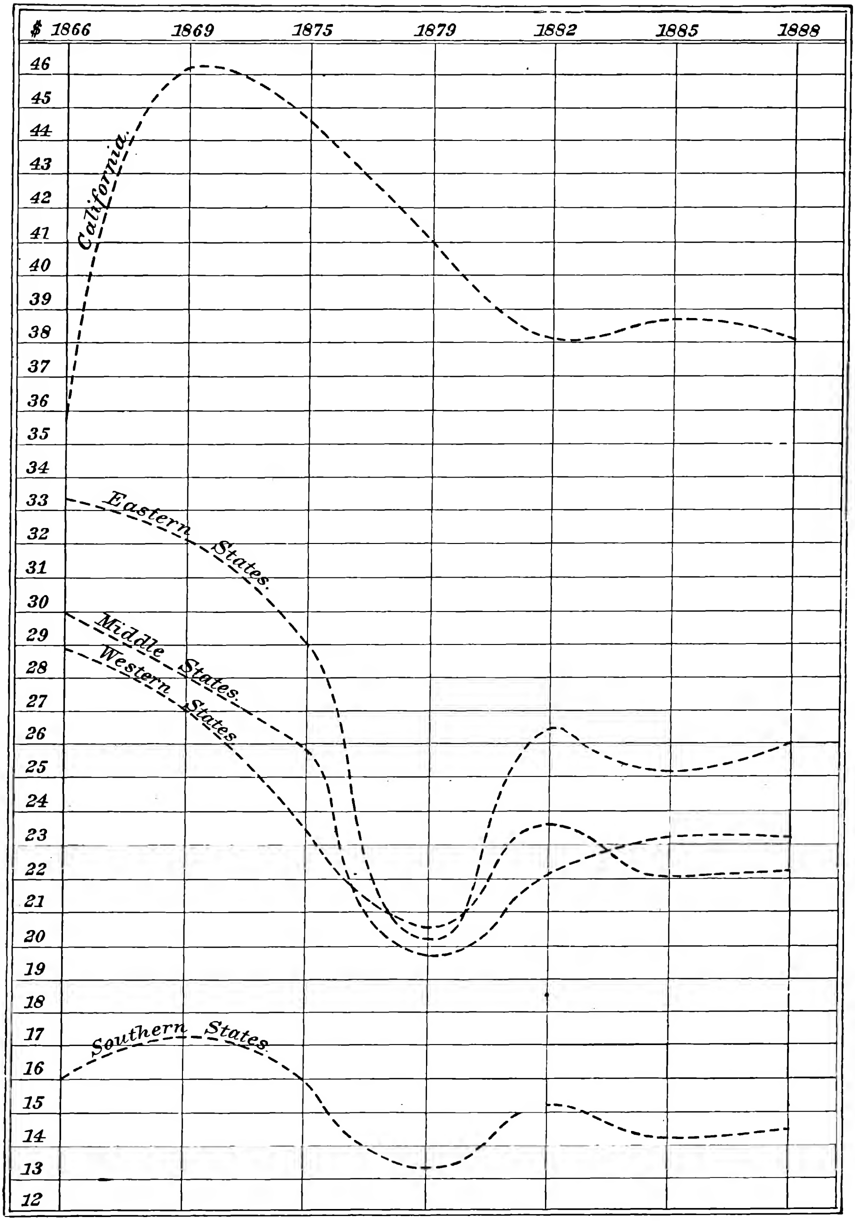
Imports of agricultural products, 1886 *and* 1887—Continued.

Articles.	1886.	1887.
Animals and their products:		
Cattle	$1,281,765	$1,392,032
Horses	4,312,636	4,872,982
Sheep	1,006,785	1,245,782
All other and fowls	338,840	305,402
Bristles	1,087,137	1,174,333
Butter	28,421	38,125
Cheese	855,570	874,261
Eggs	2,173,454	1,960,396
Hair	2,469,237	2,617,156
Hides	26,699,313	24,219,101
Meats—		
Preserved	271,512	272,651
All other	220,532	162,202
Milk	712,410	459,0[illegible]0
Oil, animal	3,488	3,387
Wools	16,746,081	16,424,479
Total animals and their products	58,207,181	56,021,289
Miscellaneous:		
Breadstuffs:		
Barley	7,177,887	6,173,208
Indian corn	8,785	16,636
Oats	30,792	29,579
Oatmeal	49,347	37,857
Rye	128,180	10,720
Wheat	331,393	218,867
Wheat flour	6,274	3,302
All other breadstuffs and preparations of, used as food, not elsewhere specified	202,818	150,059
Cotton	672,508	533,928
Farinaceous substances, etc., not elsewhere specified	693,210	721,404
Flax, hemp, jute, etc., unmanufactured:		
Flax	1,576,518	1,922,182
Hemp and all substitutes	3,817,376	4,041,522
Jute	2,267,023	2,616,1[illegible]8
Sisal-grass and other vegetable substances	2,299,450	3,733,001
Fruits and nuts	17,318,259	20,608,486
Hay	1,035,533	790,394
Hops	444,989	3,404,669
Malt, barley	237,843	153,363
Oils, vegetable:		
Fixed or expressed—		
Olive	651,590	662,197
Other	1,272,026	1,023,059
Volatile or essential	947,645	1,012,819
Rice	2,047,916	2,060,379
Seed	3,266,208	1,448,307
Spices:		
Ground	170,423	168,760
Unground—		
Nutmegs	458,879	539,291
Pepper	1,644,363	1,819,609
All other	678,936	953,752
Tobacco:		
Leaf—		
Suitable for wrappers	37,175	....
All other	7,792,832	8,704,950
Vegetables:		
Beans and peas	585,461	607,853
Potatoes	649,009	543,091
Pickles and sauces	323,362	387,177
All other—		
In their natural state or in salt or brine	528,830	516,319
Prepared or preserved	465,517	295,911
Wines:		
Champagne and other sparkling	3,110,292	3,382,907
Still wines—		
In casks	2,519,624	2,345,565
In bottles	1,310,125	1,327,613
Total miscellaneous	66,757,918	72,964,864

RECAPITULATION.

Sugar and molasses	86,369,414	83,766,699
Tea, coffee, and cocoa	60,486,718	74,789,414
Animals and their products	58,207,181	56,021,289
Miscellaneous	66,757,918	72,964,864
Total imports of agricultural products	271,821,231	287,542,266

AVERAGE WAGES OF FARM LABOR.



WAGES OF FARM LABOR.

The result of the May investigation of wages of farm labor is almost identical with that of three years ago. The changes are very slight, though local differences occur, the averages of the geographical sections or groups of States being changed very little. The average rate per month, where the laborer boards himself, is a few cents lower in the Middle and Western States and in California, and a very little higher in the South and in New England.

The highest rates obtained in 1866 in the Northern and Western States. In California and in the South there was a positive advance between that date and 1869. The investigation of 1875, a year or two after the monetary crisis appeared, showed decline in each section, which continued for several years, culminating in 1879, the date of lowest prices of all American farm products. The decline from 1866 to 1879 amounted to 39 per cent. in the Eastern States, 35 in the Middle, 30 in the Western States, and 17 in the Southern States. In California the rate of averages was well sustained, rising at first but standing in 1879 higher than in 1866.

The following statement presents the sectional averages for each period:

Sections.	1888.	1885.	1882.	1879.	1875.	1869.	1866.
Eastern States	$26.03	$25.30	$26.61	$20.21	$28.96	$32.08	$33.30
Middle States	23.11	23.19	22.24	19.69	26.02	28.02	30.07
Southern States	14.54	14.27	15.30	13.31	16.22	17.21	16.00
Western States	22.22	22.26	23.63	20.38	23.60	27.01	28.91
California	38.08	38.75	38.25	41.00	44.50	46.38	35.75
Average United States	18.24	17.97	18.94	16.42	19.87	20.98	21.71

The accompanying diagram (K) illustrates the course of prices for more than twenty years, and forcibly shows into what a gulf wages fell during the five or six years of panic, from which a slow recovery commenced in 1879. The sharp decline from 1886, except in California—where the highest point after the war is noted in 1869—is a fall from an era of inflation, in which speculative values were all the higher from being stated in a depreciated currency. The present values appear to be on a more natural and stable basis.

It will be seen that the rise was coincident with the return to specie payments, reaching the natural level by a leap as soon as the pressure which depressed was removed. It is curious to note, further, that at the lowest ebb of wages rates were higher in the West than in the Middle States, and slightly above the lowest point reached in the Eastern States, because the soil was still cultivated and crops were grown in their usual quantity, while much of the manufacturing industry was suspended. This Western line of wages would not have dipped so low but for the immigration to the West of Eastern operatives and artisans out of work seeking employment and future homes.

WAGES PER MONTH BY THE YEAR.

This statement gives the result of the present investigation, in connection with those of five prior inquiries at intervals from 1869 to 1888:

States and Territories.	1888.		1885.		1882.		1879.		1875.		1869.	
	Without board.	With board.	Without board.	With board.	Without board.	With board.	Without board.	With board.	Without board.	With board.	Without board.	With board.
Maine	$24.64	$17.20	$23.09	$16.00	$24.75	$16.15	$18.25	$11.08	$25.40	$15.94	$26.25	$16.50
New Hampshire	24.38	17.00	22.80	15.75	25.25	16.72	19.75	12.30	28.57	18.25	32.66	22.16
Vermont	23.25	16.40	23.00	16.20	23.37	16.00	19.00	11.50	29.67	19.37	32.40	21.40
Massachusetts	29.50	18.00	28.75	17.85	30.66	18.25	25.00	15.33	31.87	20.25	35.95	22.16
Rhode Island	27.75	17.50	28.50	17.70	27.75	17.00	23.00	13.25	30.00	19.00	32.25	20.00
Connecticut	27.40	17.17	27.67	17.20	27.90	17.37	23.29	14.23	28.25	18.50	33.00	20.75
New York	24.13	16.30	24.00	16.52	23.63	15.36	20.61	13.19	27.14	17.80	29.28	18.64
New Jersey	23.33	15.73	23.60	14.10	24.25	14.20	20.22	11.53	30.71	16.78	32.11	19.02
Pennsylvania	22.24	14.50	22.52	14.12	22.88	14.21	19.92	11.46	25.89	16.10	28.68	18.05
Delaware	18.00	12.25	18.33	12.63	18.20	12.50	17.00	9.50	20.33	11.67	22.00	13.00
Maryland	18.48	11.84	18.20	11.50	16.34	9.89	14.00	8.95	20.02	11.42	21.55	12.00
Virginia	13.82	9.25	13.95	9.34	13.96	9.17	11.00	7.66	14.84	9.21	15.28	9.65
North Carolina	13.41	9.00	12.85	8.91	12.86	8.80	11.19	7.66	13.46	8.82	12.76	7.91
South Carolina	12.25	8.00	12.00	8.25	12.10	8.10	10.25	6.66	12.84	8.19	11.54	7.34
Georgia	12.60	8.81	12.47	8.73	12.86	8.70	10.73	7.38	14.40	8.79	14.70	9.70
Florida	18.00	11.33	17.80	11.37	16.64	10.20	13.80	8.73	15.50	10.75	16.10	10.91
Alabama	13.59	9.49	13.00	9.10	13.15	9.09	13.20	8.30	13.60	9.40	15.19	10.52
Mississippi	15.03	10.09	14.60	10.00	15.10	10.09	13.31	9.28	16.40	11.25	17.11	11.21
Louisiana	15.37	11.12	16.05	11.26	18.20	12.69	16.40	11.27	18.40	12.20	21.37	12.62
Texas	19.20	12.60	18.87	13.72	20.20	14.03	18.27	11.49	19.50	13.37	18.83	13.21
Arkansas	18.34	12.50	17.33	12.25	18.50	12.25	17.12	11.31	20.50	13.00	25.25	16.60
Tennessee	14.00	10.00	13.88	9.74	13.75	9.49	12.73	8.69	15.20	10.00	16.81	11.00
West Virginia	18.74	12.25	19.00	12.40	19.16	12.46	16.98	10.94	20.75	13.10	21.39	13.87
Kentucky	16.51	11.33	16.80	11.69	18.20	11.75	15.17	10.00	18.12	12.00	18.84	12.57
Ohio	22.21	15.00	23.00	15.50	24.55	16.30	20.72	13.34	24.05	16.33	26.35	16.74
Michigan	25.20	17.00	24.00	16.14	25.76	17.27	22.88	14.64	28.22	18.46	31.01	20.03
Indiana	22.50	15.30	22.20	15.30	23.14	15.65	20.20	12.76	24.20	16.14	25.42	17.03
Illinois	23.20	16.00	23.50	16.60	23.91	17.14	20.61	13.01	25.20	16.87	27.32	17.69
Wisconsin	24.65	16.80	23.54	16.78	26.21	17.90	21.07	13.81	25.50	16.45	30.08	18.47
Minnesota	25.75	17.68	25.50	16.75	26.36	17.75	24.55	15.62	26.16	16.36	28.61	17.94
Iowa	25.60	17.34	25.33	17.00	26.21	17.95	22.09	13.90	24.35	16.11	28.39	17.87
Missouri	21.00	14.20	21.35	14.50	22.39	13.95	17.59	11.84	19.40	13.15	24.47	16.38
Kansas	24.25	16.05	24.70	16.00	23.85	15.87	20.67	13.28	23.20	14.65	28.90	18.38
Nebraska	25.59	17.18	25.00	16.50	24.45	16.20	23.04	14.86	24.00	14.75	33.25	19.18
California	38.08	25.67	38.75	25.00	38.25	23.45	41.00	26.27	44.50	28.60	46.38	28.69
Oregon	32.56	23.00	34.00	21.25	33.50	24.75	35.45	23.86	38.25	25.67	.....	.....
Nevada	38.00	27.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Colorado	36.00	23.00	33.00	21.25	36.50	27.08	35.00	20.00	38.50	21.14	.....	.....
Arizona	25.00	16.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Dakota	25.85	18.21	25.55	17.60	.....	.....	28.56	16.57	32.50	20.50	.....	.....
Idaho	39.00	26.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Montana	40.00	27.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
New Mexico	28.75	18.25	28.75	17.50	.....	.....	22.10	13.80	22.75	14.25	.....	.....
Utah	33.50	22.30	30.00	21.00	.....	.....	28.87	20.50	35.50	25.33	.....	.....
Washington	35.20	25.00	38.33	26.25	.....	.....	.....	.....	.....	.....	.....	.....
Wyoming	37.00	25.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average	18.24	12.36	17.97	.....	18.94	.....	16.42	.....	19.87	.....	20.98	.....

DAY WAGES IN HARVEST.

The following exhibit of average day wages in harvest time, with and without board, corresponds in its periodical changes with those in the statement of monthly wages of labor employed by the year:

States and Territories.	1888.		1885.		1882.		1879.		1875.		1869.	
	Without board.	With board.	Without board.	With board.	Without board.	With board.	Without board.	With board.	Without board.	With board.	Without board.	With board.
Maine	$1.65	$1.30	$1.58	$1.19	$1.52	$1.22	$1.42	$1.09	$1.99	$1.49	$2.17	$1.65
New Hampshire	1.67	1.37	1.65	1.32	1.71	1.35	1.25	.96	2.06	1.64	2.37	1.95
Vermont	1.65	1.35	1.68	1.30	1.75	1.35	1.29	.97	2.28	1.85	2.46	2.00
Massachusetts	1.80	1.38	1.70	1.31	1.75	1.35	1.50	1.00	1.90	1.50	2.37	1.95
Rhode Island	1.75	1.35	1.60	1.25	1.60	1.30	1.30	.95	2.00	1.50	2.37	1.75
Connecticut	1.70	1.40	1.65	1.33	1.65	1.33	1.60	1.25	2.06	1.53	2.40	1.90
New York	1.80	1.37	2.00	1.54	1.89	1.47	1.53	1.18	2.25	1.75	2.53	1.99
New Jersey	1.88	1.50	2.04	1.65	2.09	1.74	1.55	1.30	2.56	2.03	2.63	2.09
Pennsylvania	1.51	1.13	1.65	1.20	1.73	1.30	1.33	.99	2.01	1.51	2.23	1.73
Delaware	1.40	1.10	1.88	1.52	1.60	1.25	1.37	1.00	1.83	1.41	1.87	1.50
Maryland	1.46	1.15	1.74	1.38	1.52	1.15	1.43	1.12	1.81	1.34	2.16	1.67
Virginia	1.30	1.10	1.33	1.06	1.27	.99	1.16	.96	1.48	1.21	1.48	1.13
North Carolina	.96	.75	1.15	.82	1.20	.85	.99	.76	1.17	1.00	1.37	1.04
South Carolina	.95	.72	.87	.64	1.08	.78	.89	.68	1.17	1.01	1.15	.90
Georgia	.99	.77	1.04	.80	1.10	.80	.98	.61	1.29	.99	1.24	.90
Florida	1.04	.78	.96	.70	1.12	.80	1.02	.73	1.00	.72	1.25	.87
Alabama	.97	.72	.99	.76	1.05	.80	.96	.77	1.40	1.15	1.24	.95
Mississippi	.97	.73	1.00	.79	1.23	.95	1.00	.85	1.40	1.00	1.56	1.27
Louisiana	.92	.72	.95	.75	1.10	.85	1.03	.77	1.30	1.05	1.54	1.13
Texas	1.23	.96	1.32	1.04	1.39	1.08	1.30	.94	1.52	1.20	1.58	1.26
Arkansas	1.30	.97	1.30	1.03	1.34	1.02	1.38	1.08	1.50	1.25	1.67	1.40
Tennessee	1.20	.93	1.28	1.04	1.30	1.00	1.28	.98	1.62	1.20	2.10	1.59
West Virginia	1.20	.92	1.31	1.03	1.30	1.00	1.26	.95	1.55	1.20	1.78	1.29
Kentucky	1.35	1.07	1.51	1.17	1.54	1.18	1.49	1.15	1.79	1.46	1.83	1.38
Ohio	1.56	1.23	1.75	1.40	1.79	1.41	1.51	1.17	2.05	1.60	2.15	1.72
Michigan	1.80	1.40	1.90	1.57	2.13	1.76	2.02	1.55	2.50	2.00	2.76	2.25
Indiana	1.64	1.32	1.85	1.55	1.89	1.58	1.68	1.28	2.20	1.75	2.16	1.77
Illinois	1.60	1.25	1.80	1.40	1.91	1.54	1.52	1.18	2.20	1.83	2.34	1.94
Wisconsin	1.80	1.44	1.89	1.57	2.50	2.10	2.11	1.70	2.40	1.92	2.45	1.96
Minnesota	2.20	1.75	2.29	1.89	2.61	2.16	2.63	2.25	2.82	2.30	2.90	2.36
Iowa	1.81	1.46	2.00	1.61	2.25	1.81	1.66	1.57	2.57	2.10	2.85	2.24
Missouri	1.43	[illegible]	1.62	1.30	1.59	1.23	1.47	1.17	1.75	1.43	2.30	1.84
Kansas	1.60	1.25	1.87	1.48	1.70	1.35	1.70	1.32	1.86	1.46	2.08	1.63
Nebraska	1.80	[illegible]	1.98	1.55	1.95	1.57	2.17	1.66	2.40	1.98	2.41	2.00
California	2.25	1.85	2.20	1.80	2.30	1.86	2.27	1.76	2.50	2.00	2.82	2.04
Oregon	1.94	1.45	1.95	1.50	1.92	1.50	2.02	1.54	2.11	1.72	......	......
Nevada	1.80	1.37	......	......	......	......	......	......	......	......	......	......
Colorado	1.87	1.35	2.05	1.50	2.21	1.80	2.08	1.55	2.33	1.50	......	......
Arizona	1.70	1.20	......	......	......	......	......	......	......	......	......	......
Dakota	2.12	1.64	1.38	1.00	2.65	2.19	......	......	2.37	1.90	......	......
Idaho	2.00	1.52	......	......	......	......	......	......	......	......	......	......
Montana	2.20	1.50	......	......	......	......	......	......	......	......	......	......
New Mexico	1.31	1.00	1.31	.88	1.65	1.40	1.00	.67	1.35	.90	......	......
Utah	1.72	1.30	1.75	1.36	2.00	1.56	1.82	1.43	2.20	1.75	......	......
Washington	2.10	1.60	2.05	1.50	......	......	2.15	1.61	2.40	2.00	......	......
Wyoming	2.00	1.30	......	......	......	......	......	......	......	......	......	......
Average	1.31	1.02	......	......	......	......	......	......	......	......	......	......

DAY WAGES OF ORDINARY FARM LABOR.

Table showing the average rate of wages per day in transient service other than harvesting.

States and Territories.	1888.		1885.		1882.		1879.		1875.		1869.	
	Without board.	With board.	Without board.	With board.	Without board.	With board.	Without board.	With board.	Without board.	With board.	Without board.	With board.
Maine	$1.25	$0.92	$1.19	$0.88	$1.18	$0.91	$0.97	$0.72	$1.46	$1.05	$1.48	$1.05
New Hampshire	1.27	.95	1.30	.95	1.30	.97	.98	.74	1.50	1.12	1.79	1.41
Vermont	1.16	.90	1.15	.88	1.20	.90	.91	.64	1.51	1.11	1.76	1.28
Massachusetts	1.42	1.00	1.50	1.00	1.45	1.08	1.05	.75	1.44	1.12	1.92	1.37
Rhode Island	1.42	1.02	1.25	.94	1.28	1.00	1.00	.50	1.62	1.18	1.73	1.18
Connecticut	1.33	1.00	1.32	1.00	1.30	.98	1.50	.88	1.50	1.16	1.87	1.37
New York	1.21	.90	1.26	.93	1.29	.93	.92	.68	1.48	1.06	1.64	1.19
New Jersey	1.20	.87	1.17	.83	1.21	.86	.99	.68	1.45	1.00	1.63	1.15
Pennsylvania	1.10	.82	1.10	.80	1.20	.85	.96	.63	1.37	.95	1.43	1.04
Delaware	.95	.70	1.00	.78	1.10	.80	.75	.50	1.04	.70	1.30	.95
Maryland	.90	.64	.93	.62	.83	.55	.75	.48	1.06	.71	1.20	.77
Virginia	.73	.51	.71	.49	.70	.48	.63	.44	.78	.51	.80	.55
North Carolina	.61	.45	.67	.47	.68	.46	.58	.41	.72	.51	.74	.49
South Carolina	.65	.43	.60	.45	.65	.45	.53	.41	.71	.55	.70	.50
Georgia	.75	.50	.66	.47	.70	.49	.58	.44	.83	.60	.88	.60
Florida	.95	.70	.85	.60	.75	.55	.76	.53	.93	.70	.96	.72
Alabama	.72	.53	.73	.52	.72	.51	.69	.50	.75	.53	.86	.61
Mississippi	.75	.55	.80	.60	.75	.55	.78	.55	1.07	.80	1.10	.90
Louisiana	.85	.65	.82	.64	.80	.60	.85	.62	1.00	.74	1.44	.83
Texas	.95	.71	.98	.76	.93	.70	.92	.66	1.14	.84	1.16	.84
Arkansas	.93	.65	.89	.64	.88	.62	.86	.60	1.10	.80	1.36	1.02
Tennessee	.74	.53	.71	.52	.72	.50	.69	.50	.95	.60	1.05	.68
West Virginia	.85	.62	.83	.60	.82	.59	.80	.55	1.05	.75	1.14	.79
Kentucky	.82	.60	.84	.59	.87	.60	.77	.53	1.03	.72	1.10	.77
Ohio	1.07	.82	1.11	.85	1.19	.89	1.00	.83	1.35	1.00	1.44	1.05
Michigan	1.20	.90	1.28	.92	1.30	.96	1.16	.82	1.55	1.10	1.66	1.17
Indiana	1.10	.82	1.08	.80	1.08	.78	.90	.69	1.30	.95	1.36	1.01
Illinois	1.12	.84	1.14	.87	1.19	.90	1.01	.73	1.37	1.01	1.50	1.13
Wisconsin	1.22	.97	1.20	.95	1.33	.99	1.12	.79	1.42	1.00	1.56	1.15
Minnesota	1.30	1.00	1.25	.99	1.37	1.02	1.27	.94	1.50	1.07	1.64	1.18
Iowa	1.27	.97	1.31	.97	1.34	.99	1.12	.80	1.38	1.01	1.52	1.13
Missouri	.94	.80	.95	.68	1.00	.70	.67	.59	1.07	.73	1.44	1.02
Kansas	1.17	.85	1.20	.87	1.12	.80	1.05	.72	1.30	.90	1.56	1.12
Nebraska	1.37	1.00	1.35	.97	1.21	.91	1.29	.90	1.43	1.00	1.62	1.26
California	1.60	1.18	1.57	1.15	1.71	1.29	1.65	1.23	1.84	1.30	2.13	1.50
Oregon	1.35	.98	1.30	.95	1.33	1.00	1.44	1.08	1.47	1.15	....	....
Nevada	1.65	1.20	....	....	....	....	....	1.25	....	....	....	....
Colorado	1.60	1.12	1.55	1.10	1.63	1.14	1.83	1.19	1.75	1.16	....	....
Arizona	1.25	.90	....	....	....	....	....	....	....	....	....	....
Dakota	1.35	1.10	1.31	1.08	1.50	1.11	1.34	.92	1.62	1.08	....	....
Idaho	1.50	1.15	....	....	....	....	....	....	....	....	....	....
Montana	1.70	1.25	....	....	....	....	....	....	....	....	....	....
New Mexico	1.35	1.00	1.25	.81	1.28	1.00	.81	.56	.85	.50	....	....
Utah	1.42	1.10	1.52	1.14	1.57	1.10	1.46	1.12	1.80	1.40	....	....
Washington	1.45	1.15	1.70	1.17	....	....	....	....	....	....	....	....
Wyoming	1.50	1.10	....	....	....	....	....	....	....	....	....	....
Average	.92	.67	....	....	....	....	....	....	....	....	....	....

COMPARATIVE LABOR SUPPLY.

There is a sufficiency of farm labor in this country as a whole, with a comparatively even balance between the geographical divisions. There are localities in perhaps every State where scarcity exists, and others having a superabundance. There is in some places a scarcity of agricultural labor caused by demand at higher wages for labor in some specific local industry. There is reported now, as always heretofore, a tendency to exercise distinctive preferences and encourage peculiar aptitudes for professions and avocations outside of agriculture, generally leading away from the country to the town or city.

On portions of the coast the fishing industry, or other seafaring pursuits, are mentioned among those which compete with agricult-

ure for labor. In many of the counties bordering on Chesapeake Bay the supply of labor for farming purposes is somewhat scanty during the oyster season. In Maine, in portions of New York and Pennsylvania, in the yellow-pine regions of the South, and in the forest regions of the Northwest, lumbering creates a demand for labor which is sensibly felt in adjacent agricultural districts. Other forest industries whose competition is felt within certain limits are chopping cord-wood, the gathering of tan-bark, and in the Southern yellow-pine region the turpentine business. The extension of mining and the establishment of additional furnaces and iron-works have had a like effect upon agricultural labor within the sphere of their influence. The construction of railroads and various public works has created a considerable demand for labor, drawing to an inconvenient extent in some cases on the agricultural labor in their vicinity. Temporary disturbance of the relation between supply and demand has been caused by changes in rural industries from arable to pastoral, from farming to fruit-growing or market gardening. The preference of negroes to renting or owning land has caused local scarcity, and a movement to richer lands or newer settlements has had a similar effect.

Depression in manufacturing industries, total or partial suspension of work in some establishments—such as factories, iron-works, or mines—and strikes of miners, iron-workers, railroad men, or others, as causes of increased supply, are mentioned by a number of correspondents in the States bordering the Ohio and Mississippi Rivers, including West Virginia, Kentucky, Ohio, Indiana, Illinois, Wisconsin, and Missouri. It must not be inferred, however, that such conditions are extensively prevalent in those States, as the reports in question apply to only a few counties or parts of counties.

Low prices of farm produce have caused a reduced demand for hired labor, farmers and members of their families doing more of their own work than they formerly did, while there are some cases in which farmers of the poorer class have abandoned the cultivation of their own land and accepted employment from others. Increased use of machinery or improvement in its character is another cause of reduced demand referred to in many cases.

It is worthy of notice that in some of the reports from the States and Territories of the farther West the labor of the Indians is referred to as a prominent factor in the supply for farming purposes.

RENT OF FARMS.

The marked peculiarity of American agriculture has been the fact that owners of farms are the cultivators of the land. A large proportion of the farm proprietors do not employ farm laborers or pay farm wages. There are fewer laborers working for wages than owners cultivating their own acres. The whole number of farms reported in the last census was 4,008,907, the number of farmers 4,225,945, and the number of laborers 3,323,876. Since then our population has increased 20 per cent., and the number of persons, exclusive of the wives and children of farmers, who are actively employed in agriculture must be about 9,000,000. Including non-laboring children and others in the families of farmers, the agricultural population is not less than 26,000,000. The class of farm laborers must now number about 4,000,000.

In 1880 the number of farms rented was 1,024,601, of which 322,357 were taken at a cash rental and 702,244 on shares. Those that were

cultivated by owners 74.4 per cent., say three-fourths to one-fourth rented. Even this proportion of rentals is more apparent than real, as 47 per cent. of all are found in the cotton States, arising from the counting by census enumerators of individual laborers or "freedmen," to whom sections of plantations were distributed for cultivation on shares, simply because they refused to work for wages and insisted on a semblance of independent management; and thus a single farm, not to be alienated from its single owner or even divided by any permanent lines of division, was reckoned as half a dozen farms or more. Very few of these individual laborers on shares, working under various terms of contract, can be considered independent renters of farms. They are rather temporary tenant-workers of fractional parts of farms, and can not be fairly cited in proof of the gradual decadence of cultivation of lands by farm proprietors. It is an available form of cultivation, by paying wages in produce instead of cash, with a certain degree of independence of the freedmen, and a measure of protection to the farmer against the unreliability of the laborer.

The following is the census subdivision of farms by tenure:

Sections.	Total farms.	Farms cultivated by owner.		Tenant.	
		Number.	Per ct.	Cash rental.	Shares.
New England	207,232	189,572	91.5	10,230	7,430
Northern Middle	488,907	395,275	80.8	38,781	54,851
Southern Middle	167,783	116,550	69.5	17,781	33,452
South Atlantic	413,537	244,181	59.0	52,723	116,633
Southern	720,195	443,130	61.5	88,268	188,797
Western	1,214,400	956,881	78.8	73,886	183,633
Trans-Mississippi	699,766	553,608	79.1	36,066	110,092
Pacific	53,555	44,016	82.2	4,013	5,526
The Territories	43,532	41,093	94.4	609	1,830
Total	4,008,907	2,984,306	74.4	322,357	702,244

Aside from the peculiar and temporary tenures of the Southern States, about four-fifths of the farms are cultivated by their owners. There is comparatively little difference in the several geographical divisions, except that there is less tenant-holding in New England than elsewhere, there being but 17,660 farms held by any system of tenantry in the six States, and a very small proportion in the Rocky Mountain region.

The number of farms in each class, with the percentage of all cultivated by owners, for each State, is given in detail:

States and Territories.	Farms.	Farms cultivated by owner.		Farms cultivated by tenant.	
		Number.	Per ct.	Cash rental.	Shares.
Maine	64,309	61,528	96	1,628	1,153
New Hampshire	32,181	29,566	92	1,237	1,378
Vermont	35,522	30,760	87	2,164	2,598
Massachusetts	38,406	35,266	92	2,292	848
Rhode Island	6,216	4,980	80	989	247
Connecticut	30,598	27,472	90	1,920	1,206
New York	241,058	201,186	83	18,124	21,748
New Jersey	34,307	25,869	75	3,608	4,830
Pennsylvania	213,542	168,220	79	17,049	28,273
Delaware	8,749	5,041	58	511	3,197
Maryland	40,517	27,978	69	3,878	8,661

States and Territories.	Farms.	Farms cultivated by owner.		Farms cultivated by tenant.	
		Number.	Per ct.	Cash rental.	Shares.
Virginia	118,517	83,531	70	13,392	21,594
North Carolina	157,609	104,887	67	8,644	44,078
South Carolina	93,864	46,645	50	21,974	25,245
Georgia	138,626	76,451	55	18,557	43,618
Florida	23,438	16,198	69	3,548	3,692
Alabama	135,864	72,215	53	22,888	40,761
Mississippi	101,772	57,214	56	17,440	27,118
Louisiana	48,292	31,286	65	6,669	10,337
Texas	174,184	108,716	62	12,089	53,379
Arkansas	94,433	65,245	69	9,916	19,272
Tennessee	165,650	108,454	65	19,266	37,930
West Virginia	62,674	50,673	81	4,292	7,709
Kentucky	166,453	122,426	74	16,824	27,203
Ohio	247,189	199,562	81	14,834	32,793
Michigan	154,008	138,597	90	5,015	10,396
Indiana	194,013	147,963	76	8,582	37,468
Illinois	255,741	175,497	69	20,620	59,624
Wisconsin	134,322	122,163	91	3,719	8,440
Minnesota	92,386	83,933	91	1,251	7,202
Iowa	185,351	141,177	76	8,421	35,753
Missouri	215,575	156,703	73	19,843	39,029
Kansas	138,561	115,910	84	4,438	18,213
Nebraska	63,387	51,963	82	1,948	9,476
California	35,934	28,810	80	3,209	3,915
Oregon	16,217	13,938	86	741	1,538
Nevada	1,404	1,268	90	63	73
Colorado	4,506	3,922	87	165	419
Arizona	767	666	87	42	59
Dakota	17,435	16,757	96	72	606
Idaho	1,885	1,796	95	32	57
Montana	1,519	1,439	95	17	63
New Mexico	5,053	4,645	92	22	386
Utah	9,452	9,019	95	60	373
Washington	6,529	6,058	93	209	262
Wyoming	457	444	97	5	8
District of Columbia	435	269	62	150	16
Total	4,008,907	2,984,306	74.5	322,357	702,244

SHARE CONTRACTS.

There is great variety in the terms of rental for a share of the products. It is a system more popular than renting for cash in every part of the country except in the Eastern States. The three main forms of the share contract may be stated, in general terms, as (1) land only is furnished; (2) land, horses or mules, and implements; (3) all these, and feed for horses, the laborer doing the work and usually boarding himself.

In the Eastern States the preferable mode is to take the farm "at the halves," the tenant having house rent, fire-wood from the woodland, keeping the fences in condition, and dividing equally such products of the farm as are not used upon it. It is usually required that hay and coarse fodder shall be fed upon the farm, as the barnyard manure is the only ordinary resource for maintaining fertility. In some cases the owner pays for half the seed, and the tenant pays half the taxes, though required to work out the road tax. In some cases in Maine the owner receives in lieu of shares 8 to 10 per cent. of the value of the farm in cash, he paying the taxes.

The usual share of the tenant in New Hampshire is one-half; on less valuable lands, or those remote from market, he receives five-eighths. Conditions vary in minor details.

Similar terms of the share contract prevail in Vermont. One of the diversions from the regulation form of the contract is a money rent per cow on dairy farms of from $15 to $20. The tenant "at the

halves" is sometimes required to furnish half the stock and tools, or to pay interest on the investment if furnished by the proprietor.

There is very little share farming in Massachusetts, most occupiers owning the lands they cultivate; yet in a few instances in every town the share system is employed, practically the same as in the neighboring States. There are probably less than three hundred share tenants in Rhode Island, working generally for half, with considerable variation in the details of the contract.

In Connecticut the tenant getting half sometimes pays a share of the taxes and of the fertilizers, if any are used beyond the resources of the farm. Where only labor is furnished, the farm being fully equipped by the owner and work animals fed, the laborer gets one-third, or if the land is in a high state of cultivation, a fourth will sometimes suffice.

One-half is usually obtained by tenants in New York, or one-third with a minimum of provision or responsibility beyond mere labor. In some instances the taxes or the thrashing bill may be divided between the farmer and the tenant, or interest may be charged for use of stock and tools.

In New Jersey one-half is the rule in share contracts, with somewhat variable conditions, and labor alone receives one-fourth to one-third. The item of fertilizers is always important here, always considered in leases, and the quantity required affects the terms of the contract. The tenant is usually required to furnish implements, teams, and seed. In some cases the tenant is allowed two-thirds of the grain and one-half of the hay.

Pennsylvania has a great variety of forms of share contracts, allowing the tenant one-half, two-thirds, and even three-fourths of the produce, according to the value and productiveness of the land and its equipments. One-third is the usual proportion for labor only. In some cases the tenant is required to pay half of the taxes.

In Delaware the tenant gets half of the produce, and from that proportion down to one-third and one-fourth, according to his limitation of responsibility and personal expense beyond labor.

The tenant's share in Maryland, on poor or medium soils, is ordinarily two-thirds, and on more productive lands and those near to good markets one-third where only the land is furnished; but with teams and implements supplied by the owner, he gets two-fifths to one-third. Fertilizers are extensively used here, and when procured beyond the farm the tenant is usually required to pay for at least his share.

The usage varies in Virginia from one-half to two-thirds to the tenant, in some cases three-fourths. But the owner often deems it desirable to provide for the work animals when they go with the farm, especially with colored tenants, or risk the starvation of his stock. The share of labor alone is from one-fourth to one-half, according to the value of the average product of the land.

The cotton States have had a serious labor problem to solve during the past twenty years. It may not be fully solved yet, but the tendency is toward cash wages rather than a share of the crop. At first it was the only available method, as the freedman would not work for wages, preferring to become a planter himself, grow his own crops, control his own movements, and sell his own produce. The result was not altogether satisfactory to himself and not at all to the owner of the land he cultivated. Not accustomed to self-restraint,

he took too much time for amusement or idleness, entertained too much company, and ran in debt for subsistence. There were more industrious and wiser men among them who managed to accumulate something, and these, to secure greater independence and larger savings, have bought land. It is the statement of many of our correspondents that the once universal system is far less popular, is rapidly waning, and slowly becoming superseded by a return to the wage system, or to a cash rent, or its equivalent in cotton, at a certain number of pounds per acre, or a given amount, a bale, a bale and a half, and in best lands 2 bales, or 1,000 pounds of lint cotton, for a one-horse farm, say 30 or 35 acres of cotton land, in some cases including other lands for pasturage.

The share of the tenant who receives land only, and furnishes implements and supplies as well as labor, in the cotton States, is quite generally three-fourths of the cotton and two-thirds of grain or other products. Where the owner furnishes stock and implements, entirely or partially, his share of the crop increases to one-half, and in some cases two-thirds. The range of allowance for land alone may be stated at one-third to one-fifth for cotton, which is very exacting in its labor requirements, from seed to gin.

In some parts of South Carolina the laborer works four days for the use of a mule two days in cultivating his own crop. The charge for rent of horse or mule ranges from $25 to $40, as reported. Where land is rented, from $1 to $3 per acre is the usual range, according to quantity and productiveness; and the returns of lint cotton as rent of land is equally variable, from 500 to 1,000 pounds for a one-mule farm (say 35 acres), and in one instance 100 pounds per acre is reported, which appears to be an extreme rent. The tenant is usually allowed land for a garden, the privilege of taking fire-wood, and often pasturage for a cow or two or several hogs.

The share of the tenant in West Virginia is one-half to two-thirds, according to value and capabilities of the farm, he providing the stock and implements. Various forms of contract are made, in which the owner furnishes more than the land and obtains a larger share of the products.

One-half to two-thirds is the ordinary rule in Kentucky; in some cases one-half of the tobacco and two-thirds of the corn. Some correspondents say one-half of the corn and two-fifths of the tobacco. In some counties half of the corn is taken by the tenant and two-thirds of the oats.

In Ohio one-half to two-thirds is usually taken by the tenant. In same cases one-half of the hay and two-thirds of the other crops is the rule. There are various modifications of the contract. A tenant who has house, garden, and pasture may receive only half, when he might obtain two-thirds if he had the land alone. The Ottowa reporter says the most satisfactory plan is for the tenant to furnish half the stock, half seed, and pay half the tax on personal property and half the repairs, and divide equally the products.

In Indiana the farm is usually taken "at the halves." Sometimes two-fifths or two-thirds is the custom. Where uplands are farmed for two-thirds or three-fifths, bottom-lands are sometimes taken at one-half. For labor alone the tenant gets one-third; in best lands one-fourth. Similar practice prevails in Illinois, the tenant receiving one-half, two-fifths, and sometimes two-thirds, according to land and requirements aside from labor. In Douglas County one-third of small grain goes to the tenant and two-fifths of the Indian corn

and broom-corn. On well-drained bottom-lands one-half is the tenant's share, while he gets two-thirds on less productive soils.

The renter gets from one-half to two-thirds in Wisconsin. There is considerable variation in Minnesota, from one-half to three-fourths to tenant being reported. In Mower County "the usual contract is for owners to furnish land, seed, grain, and sometimes part of machinery, and give one-half of crop." In Rice "one-half is given when the laborer furnishes his team, seed, etc." This plan is reported for several counties. If the bare land or land with house is furnished, the tenant gets the larger proportion, two-thirds at least. In Dodge the prevailing usage is to furnish land, seed, and pay half the thrashing bill, owner and tenant dividing equally. The main cause of variation is the relative productiveness of the farm; otherwise conditions depend upon what is furnished besides the land.

The contract in Iowa is generally for one-third to the owner and two-thirds for the tenant, if the renter furnishes everything; otherwise the tenant gets half. In some cases it is half the hay and two-thirds of the grain, both harvested and garnered. In some cases the owner furnishes seed and pays half the thrashing bill, getting half of the crop.

In Missouri two-thirds to the tenant is usual, when only land is furnished, one-half to two-fifths when horses and implements go with the land, and one-third when the horses are fed in addition, and sometimes only one-fourth.

The prevailing custom in Kansas is to give two-thirds to the tenant who furnishes everything but land, though the rule varies, and the range is from one-half to three-fourths. The compensation for labor alone is one-fourth to one-third. One-third to the owner for land alone, and one-third for labor done, the other third going for outfit and feed of animals, to owner or tenant, whoever furnishes it. In some counties it is said that there is more land broken than is cultivated, and land can sometimes be had free, especially tree claims before the trees are set out. Two-thirds to the tenant furnishing all is the usual custom in Dakota. When the owner furnishes land, house, barn, all seed, and pays for half the thrashing, the crop is equally divided.

Similar terms are given in other Territories. In Idaho a tenant can get land the first year free if he does the breaking. For labor alone one-third is usually given. Land and teams command one-half the product. When only land is rented three-fourths of the crops are sometimes taken by the tenant.

The contract most in vogue in California gives two-thirds to the tenant who furnishes the farm equipments, using only land. In extreme cases he gets three-fourths. In San Benito the tenant pays 50 cents per acre and one-fourth of the produce. In Alameda and other counties he receives three-fourths of the grain and two-thirds of the hay. Similar terms prevail in Oregon, in most cases the tenant receiving two-thirds of the crops. Very few farms are occupied by tenants in Washington Territory. Where the practice prevails the terms are like those of Oregon and California.

INTERNATIONAL STATISTICAL INSTITUTE.

Great progress has been made in statistics in the past forty years, in the topical extension of statistical inquiry, in the machinery of collection, in accuracy of enumeration, in comprehensive co-ordination, rational deduction, and general utilization of the results of statistical research. The atoms of statistics, the original data, are of little value if separate, but they are potent in statesmanship, political economy, and every branch of human effort and industry, if aggregated and correlated in comprehensive and symmetrical proportions. In these day of international commingling, by commerce, immigration, and travel, demand for statistics more comprehensive than national statements have arisen, and international comparisons have therefore become an urgent necessity of progress in government, industry, and the arts.

This want became so urgent that in 1853 there was organized at Brussels, largely through the instrumentality of M. Quetelet, the International Congress of Statistics. The second session was held at Paris in 1855; successive sessions were held at Vienna in 1857, London in 1860, Berlin in 1863; Florence in 1867, The Hague in 1869, St. Petersburg in 1872, and Buda-Pesth in 1876. They were largely attended; there were 153 members at Brussels and 751 at Florence, the tendency being to constant enlargement, and the average of the nine sessions being 486. A large amount of work was done, methods of investigation were improved, the world was made the field of statistical inquiry, valuable international statements were prepared, some of especial value to agriculture, in reference to superficial and productive areas of states, number and size of farm holdings, areas in various crops, and quantity of farm products. There were good reasons for its existence, and a fair show of good fruits of its life, and yet it has been dead for a decade. It died of plethora, of too much blood, some of it bad blood. It was an unwieldly body, so large that the highest statistical experience was overborne by force and pressure of inexperience. It was too loosely organized, its gates too easily passed, and hence its counsels were divided and the value of its results impaired. The sessions, each in succession held in a new location, were controlled by a local majority, rendering impossible a settled and persistent policy of action.

With this experience, valuable for its failures no less than for its successes, a new organization was effected in 1885, at the fiftieth or jubilee anniversary of the London Statistical Society, called the International Statistical Institute, a permanent institution, with membership limited to official and scientific statisticians of recognized ability and experience. Its sessions are to be biennial, for more intimate association and discussion of means of promoting international agreement in statistical methods and statements, while the main work in this line of progress is to be done *ad interim* by individuals in harmony with the spirit of the Institute's official work.

The first meeting was called at Rome in 1886, but on account of the presence of cholera there in the summer months it was postponed from September to April of the present year. The session was opened on the 12th of April, under the presidency of Sir Rawson W. Rawson, of London, who was assisted by Vice-Presidents Prof. Emile Levasseur, member of the Institute of France, and Prof. F. X. von Neumann-Spallart, of the Vienna University. The secretary was M.

Luigi Bodio, director-general of statistics of the Kingdom of Italy, and the treasurer, Mr. John Biddulph Martin, the foreign secretary of the Statistical Society of London. The following active members participated, representing the countries indicated:

Great Britain.—Alfred Edward Bateman, Maj. Patrick George Craigie, Dr. Leone Levi, John Biddulph Martin, Dr. Frederic John Mouat, Richard Henry Inglis Palgrave, Sir Rawson W. Rawson.

France.—Dr. Jacques Bertillon, Emile Cheysson, Alfred de Foville, Octave Greard, Emile Levasseur, Toussaint Loua, Leon Say, Dr. Leon Vacher, Emile Joachim Yvernes.

Germany.—Dr. Ernst Engel, Dr. Wilhelm Lexis, Dr. George von Mayr, Dr. Adolph Wagner.

Austria-Hungary.—Dr. Josef von Jekelfalussy, Dr. Charles Keleti, Joseph Korosi, Dr. Oscar von Meltzl, Dr. Franz Xavier Ritter von Neumann-Spallart, Dr. Karl Theodor von Inama-Sternegg, Max Wirth.

Switzerland.—Guillaume Edmond Milliet.

Italy.—Gerolamo Boccardo, Luigi Bodio, Leoni Carpi, S. E. Cesare Correnti, Giacomo Costa, Giovanni Battista Favero, Dr. Carlo Francesco Ferraris, Major General Annibale Ferrero, Fedele Lampertico, Luigi Luzzati, Agostino Magliani, Angelo Messadaglia, Carlo De Negri, Maffeo Pantaleoni, Luigi Perozzo, Dr. Enrico Raseri, Vittorio Ellena.

Denmark.—Marius Gad, Dr. William Scharling.

Russia.—Fr. von Jung Stilling, Nicolas Troinitsky.

Norway.—Dr. Ole Jacob Broch.

Spain.—Don Carlo de Ibanez.

United States of America.—J. R. Dodge.

There were also present and participating, by official invitation, the Duke of Torlonia, mayor of Rome, twenty-two members of the Italian Conseil Superieur de Statistique, professors of the University of Rome, directors of several branches of the imperial statistical service, and the minister of Brazil at Rome; in all, thirty-four persons.

The first meeting of the first session of the institute, held in the palace of the minister of finance, was opened at 10 o'clock a. m., Tuesday, April 12. The president, on taking the chair, in behalf of the institute thanked the Italian Government for its hospitality, especially in providing a place of meeting in one of its most beautiful palaces, and proposed to the assembly to constitute M. Grimaldi, minister of agriculture, industry, and commerce, by acclamation, an honorary member of the institute, an honor already conferred upon M. Magliani, minister of finance. M. Grimaldi then made an address of welcome, in which he referred to the dependence of politics upon science, and the aid of statistics in conferring significance and elevation upon the endeavors of statesmanship, and thanked the body for its coming to offer scientific contributions in aid of practical politics. In this connection he said:

Thus, gentlemen, between your studies and the labors of the politician there exists a close bond. Statisticians and statesmen serve the same cause by different means. Politics (I speak of the interior administration of civil communities) finds in statistics a valuable auxiliary, often a guide. It owes it much; it will owe it yet more, according as statisticians extend the scope of their researches and perfect the methods of their investigations. Therefore, gentlemen, the Italian Government is honored in the choice you have made of Rome for holding the first session of the institute, and receives you with a cordial sympathy. For a long time Italy has apprehended the rôle of statistics and the double interest that its works have for science and administration. She has proved it. You have been witness of the efforts

that she has not ceased to make since the foundation of the Kingdom to multiply in all useful ways researches of this kind, to direct and control them properly—thanks to a strong central organization—and to give to the results a large publicity. We salute, then, with pleasure, your institute, because it is itself the champion of a cause which is dear to us.

He referred at some length to the proposed work of the session, and discussed with much discrimination and appreciation prominent topics of the programme, and said relative to the position of his own Government:

You are well enough acquainted with our legislation to know that Italy has not remained indifferent to the amelioration of the condition of the masses, and that she has resolutely entered the movement which influences civilized states to give a leading place to these grave questions upon the political programme of the day.

The president, in response, expressed the grateful acknowledgment of the institute to the minister and the Government for kindliness, encouragement, and support so generously lavished upon the infancy of this institution. Referring to the personnel of the membership, he said:

I see before me a large assembly of men, many of whom occupy, among their compatriots, the highest positions, and who are themselves illustrious by their researches and by their works. Why have they assembled here from all points of Europe and even from America?

He reviewed the progress of statistics, the development of the idea of international organization, from the creation of the first national society of statistics in London in 1834, and the origin of the International Congress in 1853, tracing the movement of its progress to the ninth and last session in 1876, with suggestions from this experience for the guidance of the new organization. He urged an early effort for the preparation and publication of a complete bibliography of international statistics as an essential initiative to the international work proposed.

After the delivery of these opening addresses, the perfecting of the organization became the first business in order, the revision of the statutes, in accordance with article 17. Amendments were presented, one of the most important being the restriction of membership to one hundred and fifty active members. These were discussed, acted on, and the entire constitution adopted, as amended, as follows:

Article I.

The International Statistical Institute is an international association which has for its object the development of the progress of administrative and scientific statistics:

First. By seeking and recommending the proper methods to obtain, as far as possible, uniformity in the schedules and in the compilation of statistical returns, in order to render comparable the results obtained in the different countries.

Second. By inviting the attention of governments to the questions to be solved by statistical investigations.

Third. By preparing international publications destined to elucidate statistical questions, and to establish permanent relations between statisticians of all countries.

Fourth. By co-operation, if there is occasion, by other publications, by instruction, and by various means of propagating statistical knowledge and interesting statesmen and savants in the investigation of social facts.

Article II.

As a general rule the International Institute will be held every two years. At each session the place and time of the next session will be designated. In case the assembly makes no decision in this respect the designation will be made by the Bureau.

ARTICLE III.

The International Institute is composed of titulary and honorary members.

ARTICLE IV.

The International Institute chooses its members among men of diverse nations who are distinguished in the domain of administrative or scientific statistics, such as chiefs of official statistics, members of central commissions or statistical bureaus of states or large towns, members of statistical societies, and other savants.

The number of titular members can not exceed 150, but need not necessarily attain that figure.

ARTICLE V.

Before each session persons charged with a statistical service, who may not be members of the International Institute, may be invited by the executive committee to take part at the session and have deliberative voice, except in questions of interior administration and for elections.

ARTICLE VI.

There can not be accorded to the same state or to a confederation of states a number of members exceeding the fifth of the total number of the members elected.

ARTICLE VII.

The title of honorary members can be conferred: First, on titular members; second, on persons who are popular in the domain of statistics.

The honorary members receive gratuitously the publications of the International Institute, and enjoy all the rights and prerogatives of the titular members.

ARTICLE VIII.

At the end of each ordinary session it proceeds to the election of a president, two vice-presidents, one general secretary, and one treasurer, who enter immediately *en function*, and constitute to the close of the following session the Bureau of the International Statistical Institute.

The members of the Bureau are re-eligible.

ARTICLE IX.

The Bureau is charged with the administration of the International Institute. The president, in case of urgency, takes the measures that he judges necessary, but communicates afterward his decision to the other members of the Bureau.

ARTICLE X.

The general secretary is charged with editing the official reports of the seances, and, in concert with the president, with the correspondence, with the publications, and the execution of the decisions of the International Institute, except in cases where the institute itself has provided otherwise. He has the care of the archives. His residence is considered the seat of the institute.

The general secretary can associate with himself one or more secretaries or employés to aid him in the exercise of his functions.

ARTICLE XI.

The treasurer is charged with the financial management and the keeping of the accounts. He presents at each ordinary session a report for the financial years passed.

Two members are designated at the opening of each session in the capacity of auditors to examine the report of the treasurer, who makes a report in course of the session.

Article XII.

When the time arrives for the election of members of the International Institute the president distributes a month before the commencement of the session a list of all the names of whom the candidateship have been proposed to him with the signatures of at least five members of the institute.

The election takes place by *scrutin de liste* unless five members claim individual ballot. Vote by correspondence is admitted; in this case it is made always by balloting upon the list.

It is required for election a majority of three-fourths of the votes cast. In case two candidates have obtained the same number of votes for the same place, there will be a reballoting, at which only the members present will take part.

The election of members of the Bureau is made by secret ballot by individual vote and the majority of votes cast. The members present have sole right of suffrage.

As a general rule, in the meetings of the International Institute the resolutions, except in the case of the election of members, are adopted after discussion by a majority vote.

Whenever there is vote by nominal call, the names of the members who have voted for and against, or who have abstained, are mentioned in the official report.

Article XIII.

The International Institute names among its members reporters or constitutes commissions for the preparatory study of the questions which may be submitted to its deliberations, and for the composition and editing of special publications in the domain of international statistics. In the interval of the sessions the same prerogative appertains to the Bureau; in case of urgency the general secretary, in accord with the president, prepares the reports or the conclusions.

Article XIV.

The International Institute will publish:

First. A quarterly bulletin.

This bulletin will contain:

(*a*) Report of the sessions of the International Statistical Institute;

(*b*) Reports upon the organization and reforms of the official statistics of the different countries upon the changes in personnel, etc.;

(*c*) Works of international statistics;

(*d*) Résumé of the recent and most important works upon statistics;

(*e*) An international bibliography of statistics, giving the catalogue of recent publications, the contents of reviews, annual and bulletin periodicals of statistics.

Second. An annual of international statistics.

This annual will contain international statistical comparisons which will be established according to information furnished by the different countries.

Article XV.

The financial resources of the institute are:

First. The assessment of the titular members, fixed at 1 pound sterling=20 marks=25 francs. These assessments are due from and include the financial year of the election. They give right to all the publications of the institute from the year of the election.

The financial year dates from the 1st of July to the end of June. A delay of two years, not justified, in the payment of the assessment will be considered as equivalent to a resignation.

The assessment can be commuted by a sum of 10 pounds sterling=200 marks=250 francs.

Second. The assessment and subscriptions of the central commissions, official bureaus, and statistical societies of the different countries, which acquire thus a right to a certain number of copies of all the publications of the International Institute for the current year.

Third. The endowments and other donations.

It is proposed to form a reserve fund, the revenues of which will be applied to the expenses of the International Institute.

ARTICLE XVI.

The present statutes will be revised by the assembly only upon the written request of twenty-five members. That request should be addressed to the president, with motions in support of it, at least three months before the opening of the session.

It is quite impracticable to give in the present report more than a mention of the work of the institute during the session. The morning hours were devoted to the sessions of the several committees, the principal of which related to lands, prices, census enumerations, labor, commerce, and the bibliography of statistics.

In the committee on prices one session was devoted to the consideration of the best means of procuring and presenting records of mean prices of the products of agriculture, industry, and transportation, to serve as a base to measure the variations of price at different periods and the divergency of price in different countries.

The committee on landed property canvassed the best means of preparing comparative statements relative to the division of lands and upon the extent of agricultural holdings in different countries, showing the status of cultivators, whether proprietors, tenant farmers, or share-renters. In this committee a memorandum was submitted by Maj. P. G. Craigie, of England, which illustrated the wide variation in forms and methods of inquiry, the divergence of definitions in such terms as "agricultural holding" and "cultivated land," the errors arising from resulting figures not strictly comparable, the confusing variety of grouping of returns of holdings, the failure of census records to show the number of land owners, and the failure to show with precision the number of separate properties. Belgium, for example, enumerates the smallest areas, England those of not less than a fourth of an acre, the United States three acres, Hungary five, etc. After discussion, in which the members of different countries presented the local usage and personal view of the difficulties to be surmounted, M. de Foville, of France, showed the practicability of attempting some agreement on the more important points presented, and a permanent international committee was organized to collect the precise facts of existing records and formulate a practicable plan of unification of statements for international comparison.

The committee on labor gave an entire morning to the consideration of means of procuring comparative data of the statistics of labor of different countries. Statements were made concerning researches and investigations in those directions in France, Italy, the United States, and other countries. Suggestions were made by several heads of statistical bureaus, and a committee was organized for more thorough investigation *ad interim*.

The census committee held a long session in consideration of the differences existing in publications relative to census enumerations, and the means of rendering their facts more readily comparable. Another committee devoted considerable time to discussion as to the possibility and the means of rendering more comparable the results of official statistics of foreign commerce of different nations. Still another investigated the means of preparing for each country a catalogue of publications, official and other, containing exact statements for each of the principal branches of statistics. These hints of the work of committees suggest some of the difficulties to be overborne, and afford a glimpse of the wide field of future work *ad interim* and at biennial sessions.

The afternoon sessions were mainly occupied with the reading of previously-prepared papers and discussions of their subject-matter by members. The principal of these were:

Dr. Ernst Engel: Consumption as a measure of the welfare of individuals, families, and nations.

M. Charles Keleti: Upon the food-supply of the Hungarian people.

M. Cheysson: Forms for a *monographie d'atelier*.

Dr. Neumann-Spallart: Upon a better method of appreciating the social and economic state of a country at a given epoch.

M. Luzzatti: The difficulties which oppose the establishment of a statistical comparison of the debts of states.

Dr. Inama-Sternegg: The means of developing historical statistics.

M. Emile Lavasseur: Study of the condition and movement of population in France in the eighteenth century.

M. Charles Ferraris: Examination of the peculiar difficulties of tracing the movement of the precious metals in international commerce.

Dr. Leon Vacher: The diminution of mortality and increase of the average length of life in Europe.

M. Kiaer: On the fecundity of marriages.

Dr. Broch: On the consumption in Europe of modern stimulants—alcohol, coffee, tea, cocao, sugar, and tobacco—and on the receipts of states for imports levied thereon.

TRANSPORTATION RATES.

In complying with the requirements of Congress, through and local rates of freight have been published in each monthly statistical report of this Department during the past year, showing the cost of transportation of all principal products of agriculture from the principal points of shipment in all parts of the country to large market centers; also tables of transatlantic rates over several of the more important steam-ship lines. All of the rates published are those in operation upon the first day of each month, and do not show the changes made between the reports.

By carefully analyzing these rates, using those from Chicago to New York, as they are the basis of all rates over any of the trunk lines from points east to New York, it will be seen that they varied very little during the year, with the exception of the last month, when the rates upon live stock and dressed meats were greatly reduced, and fluctuated from 3 to 5 cents a day for several days, owing to a disagreement between the American lines and the Grand Trunk Road as to the rates upon exports and dressed meats.

January 1, 1887, the rates on cattle in car-load lots were reported at 35 cents per 100 pounds, Chicago to New York, and continued the same until December 1, when they were reported at 16½ cents. Sheep, car-load, were reported at 45 cents, January 1; dropped to 40 cents May 1, and December 1 to 19 cents. Hogs were 35 cents to July 1 and 30 the remainder of the year. Grain and flour began with 30 cents, and from May 1 continued at 25 cents. Lard and pork opened at 35 cents, and from May 1 continued at 30 cents. Dressed beef continued at 65 cents from January to December, when it was reported at 31 cents. As a means of comparison the following table is presented, showing the rates per 100 pounds from Chicago to New

York upon certain products, as reported by several trunk lines upon the first day of each month for the years 1884, 1885, 1886, and 1887:

Months.	Cattle, car-load.				Sheep, car-load.				Hogs, car-load.			
	1884.	1885.	1886.	1887.	1884.	1885.	1886.	1887.	1884.	1885.	1886.	1887.
	Cts.	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*
January 1	60	40	25	35	60	50	25	45	35	30	30	35
February 1	60	40	25	35	60	50	25	45	35	30	30	35
March 1	60	40	35	35	60	50	45	45	25	30	30	35
April 1	60	40	35	35	60	50	45	45	20	25	30	35
May 1	60	40	35	35	60	50	45	40	20	25	30	35
June 1	50	30	35	35	50	40	45	40	20	25	30	35
July 1	30	25	35	35	40	40	45	40	25	20	30	30
August 1	30	25	35	35	40	40	45	40	30	25	30	30
September 1	20	25	35	35	40	40	45	40	30	25	30	20
October 1	20	25	35	35	40	40	45	40	30	25	30	20
November 1	20	25	35	35	40	40	45	40	30	25	30	30
December 1	20	25	35	16½	40	40	45	19	30	30	30	30

Months.	Grain and flour, car-load.				Lard and pork, car-load.				Dressed beef, car-load.			
	1884.	1885.	1886.	1887.	1884.	1885.	1886.	1887.	1884.	1885.	1886.	1887.
	Cts.	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*
January 1	30	25	25	30	35	30	30	35	64	70	43½	65
February 1	30	25	25	30	35	30	30	35	64	70	43½	65
March 1	30	25	25	30	35	30	30	35	64	70	65	65
April 1	15	20	25	30	20	25	30	35	64	70	65	65
May 1	15	20	25	25	20	25	30	30	64	70	65	65
June 1	15	20	25	25	20	25	30	30	48	70	65	65
July 1	20	15	25	25	25	25	30	30	48	43½	65	65
August 1	25	20	25	25	30	25	30	30	48	43½	65	65
September 1	25	20	25	25	30	25	30	30	32	43½	65	65
October 1	25	20	25	25	30	25	30	30	32	43½	65	65
November 1	25	20	25	25	30	25	30	30	32	43½	65	65
December 1	25	25	25	25	30	30	30	30	32	43½	65	31

The following table shows the rates on wheat and corn from Chicago to New York, via the three great routes—lake and canal, lake and rail, and all rail—for the years 1876 to 1886, inclusive. The rates for 1886 were higher than for any year since 1880, with the exception of the all-rail rates for 1883, which were 1.12 cents higher on corn and 1.20 cents on wheat.

Calendar year.	Corn.			Wheat.		
	By lake and canal.	By lake and rail.	By all rail.	By lake and canal.	By lake and rail.	By all rail.
	Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1876	8.75	10.79	15.74	9.82	11.36	16.86
1877	9.59	14.06	18.90	11.09	15.46	20.50
1878	8.83	10.53	16.52	9.96	12.09	17.70
1879	10.49	12.20	14.56	11.87	13.13	17.74
1880	13.41	14.43	17.48	13.13	15.80	19.80
1881	7.77	9.42	13.40	8.67	10.49	14.40
1882	6.72	10.28	13.50	7.23	10.91	14.47
1883	8.03	11.00	15.12	9.01	11.63	16.20
1884	6.55	8.50	12.32	7.00	10.60	13.20
1885	6.30	8.01	12.32	6.54	9.02	13.20
1886	8.45	11.20	14.00	9.10	12.00	15.00

TRANSATLANTIC RATES.

During the past year the cost of transporting our agricultural surplus to foreign markets has been exceedingly low. The year

opened firm at 5 pence per bushel for carrying grain from New York to Liverpool, but gradually declined to May 1, when the rate was reported at 1½ pence; June 1, 2 pence; July, 2½ pence; August, 3 pence; September and October 1, 2 pence; November, 3½ pence, and December, 3 pence. The true average rate for the year has not been ascertained, but the straight average according to the returns upon the first day of each month is 2.71 pence. These are steamer rates.

As to sailing-vessel rates the following is from a letter received from J. C. Brown, esq., statistician New York Produce Exchange, which shows that this business, once so large and profitable, has dwindled to practically nothing. He says:

I have consulted a number of the most prominent and best-informed freight agents here, who unanimously say that there is no business of the kind done between the ports you name in wheat or corn, practically all being done by regular steam liners, or by charter (steam) "Cork for orders." A thorough search of records from the beginning of 1881 discloses only 17 sailers carrying wheat or corn to Liverpool (these only as part cargo), of which 10 sailed early in 1881, leaving but 7 within the period you name. The 10 in 1881 followed the noted "Lyons corner." Of the 7 within the period you name, 1 in 1882 (and the only one that year) carried corn as through freight from the West, and of the remaining 6, 3 in 1885 were taken at the time of the "war scare," and the securing of cheaper storage after arrival than if sent by steam undoubtedly was a factor in their being taken. The majority of these vessels are what you might term mere fugitives, belonging elsewhere, here by accident or chance, and taking grain as part cargo for weight to aid them in getting back where they belonged or had to go. Wheat by sail, New York to Liverpool, is a thing of the past.

Average cost per bushel for transporting wheat from New York to Liverpool, from 1866 to 1887, inclusive.

[NOTE.—Pence reduced to cents at 2 cents per penny.]

Years.	Steamer rates.		Sailing-vessel rates.		Years.	Steamer rates.		Sailing-vessel rates.	
	Pence.	*Cents.*	*Pence.*	*Cents.*		*Pence.*	*Cents.*	*Pence.*	*Cents.*
1866	4.74	9.48	......	......	1877	6.93	13.86	6.76	13.52
1867	5.18	10.36	......	......	1878	7.61	15.22	7.09	14.18
1868	7.18	14.36	......	......	1879	6.2	12.4	5.9	11.8
1869	6.4	12.98	......	......	1880	5.88	11.76	5.1	10.2
1870	5.78	11.56	......	......	1881	4.08	8.16	4.75	9.5
1871	8.16	16.32	......	......	1882	3.87	7.74	......	......
1872	7.64	15.28	......	......	1883	4.54	9.08	6.25	12.5
1873	10.56	21.12	9.91	19.82	1884	3.4	6.8	5	10
1874	9.08	18.16	7.83	15.66	1885	3.6	7.2	......	......
1875	8.07	16.14	7.12	14.24	1886	3.46	6.92	......	......
1876	8.02	16.04	7.64	15.28	1887	2.71	5.42	......	......

Average monthly prices paid for carrying grain from New York to Liverpool during the years 1884, 1885, 1886, and 1887.

Months.	1884.		1885.		1886.		1887.	
	Pence.	*Cents.*	*Pence.*	*Cents.*	*Pence.*	*Cents.*	*Pence.*	*Cents.*
January	2.35	4.70	5	10	3.75	7.5	5	10
February	2.24	4.48	4.5	9	2.5	5	3.5	7
March	1.56	3.12	3	6	2.5	5	3	6
April	1.77	3.54	4	8	3.5	7	1.5	3
May	1.25	2.5	3.5	7	4	8	1.5	3
June	3.08	6.16	3	6	4.5	9	2	4
July	4.71	9.42	2.75	5.5	3	6	2.5	5
August	4.68	9.36	3	6	2	4	3	6
September	3	6	3.5	7	3	6	2	4
October	4	8	4	8	4	8	2	4
November	5.79	11.58	4	8	4.25	8.5	3.5	7
December	6.37	12.74	3	6	4.5	9	3	6

TRANSPORTATION OF MILK.

During the month of July an investigation was made and published in the August crop report as to the charges for transporting milk to several of our largest cities, and a comparison was shown with the foreign rates to London.

FOREIGN MILK RATES.

The four railroads carrying over 20,000,000 gallons of milk to London per annum are the London and Southwestern, Great Eastern, London and Northwestern, and Great Western. The mileage tariff of the London and Southwestern, which seems to be about the same as the other companies, is as follows:

[Reduced to U. S. currency on the basis of 2 cents per penny.]

Miles.	Cans of 6 gallons.			Cans of 9 gallons.			Cans of 12 gallons.			Cans of 15 gallons.			Cans of 18 gallons.		
	s.	*d.*	*Cents.*	*s.*	*d.*	*Cents.*	*s.*	*d.*	*Cents.*	*s.*	*d.*	*Cents.*	*s.*	*d.*	*Cents.*
10 miles and under	0	6	12	0	7	14	0	8	16	0	9	18	0	10	20
10 to 25	0	7	14	0	8	16	0	9	18	0	10	20	0	11	22
25 to 40	0	8	16	0	9	18	0	10	20	0	11	22	1	0	24
40 to 50	0	9	18	0	11	22	1	1	26	1	3	30	1	5	34
50 to 75	0	11	22	1	1	26	1	3	30	1	5	34	1	7	38
75 to 100	1	2	28	1	4	32	1	6	36	1	8	40	1	10	44
100 to 125	1	4	32	1	6	36	1	9	42	2	0	48	2	4	56
125 to 150	1	6	36	1	8	40	2	0	4[illegible]	2	3	54	2	6	60
150 to 175	1	8	40	1	10	44	2	2	52	2	6	60	3	9	66

It will be seen that the difference in the cost of the several sizes of cans for 40 miles and under is 2 cents per can, while from 40 to 100 miles it is 4 cents. These differences are proportional throughout the table, with one or two exceptions, according to the distance and size of cans. The greatest difference is the 18-gallon can, between 100 and 125 miles, which is 12 cents, and between 40 and 50 miles, 10 cents; while between 125 and 150 miles the difference is only 4 cents.

DOMESTIC MILK RATES.

The rates on milk for long distances in this country generally are not as high as the foreign rates indicated above. For instance, the rates to Jersey City for a 10-gallon can over the New York, Lake Erie and Western Railroad for 175 miles is 35 cents per can, which is 5 cents less than the foreign rate on a 6-gallon can for the same distance to London. For a short distance the foreign rate is much smaller, *i. e.*, the foreign rate for 25 miles to London on a 9-gallon can is only 16 cents per can, while over the New York, Lake Erie and Western Railroad for twenty-five miles on a 10-gallon can is the same as for 175 miles, 35 cents per can. Over the New York Central and Hudson River Railroad from all points on the Hudson River and Harlem divisions to New York City, the long-distance rate, say 125 miles, for a 10-gallon can of milk is 30 cents per can, while the foreign rate to London for the same distance on a 9-gallon can is 36 cents. The foreign short-haul rate is, as in the case of the New York, Lake Erie and Western Railroad, much smaller than the domestic rate, which is the same as for a long haul, while the foreign rate for a 9-gallon can for 25 miles is 16 cents per can, or only 1 cent more than one-half of the domestic rate for the

same distance. The West Shore Railroad Company transports milk in 40-quart or 10-gallon cans from Kingston, 88 miles, and intermediate points of shipment to Weehawken, a short distance from Jersey City, for 35 cents per can, and from Utica, about 230 miles, 38 cents per can.

Different railroad companies have different ways of charging for the transportation of milk. Some companies' rates are by the can of a certain capacity, others charge a certain rate per quart, a few charge so much per gallon, and others a rate per 100 pounds.

The rates over the Boston and Lowell Railroad to Boston, from 4 to 220 miles, are as follows:

[In cents per 100 pounds.]

Station.	Miles.	Rate.	Station.	Miles.	Rate.
North Somerville	4	5	Keene	96	26
Winchester	8	5	East Andover	100	30
South Wilmington	13	7	South Danbury	110	31
North Billerica	22	8	Grafton	118	33
Lowell	26	9	Enfield	133	34
Tyngsborough	32	12	Lebanon	140	35
Nashua	40	12	White River Junction	145	36
Amherst	48	16	Haverhill	160	37
Milford	51	17	Woodsville	168	38
Wilton	55	18	Lisbon	178	39
Greenfield	66	20	Littleton	189	40
Hancock	74	22	Bethlehem Junction	198	42
East Harrisville	79	23	Fabyans	208	43
Chesham	85	25	Groveton Junction	220	45

It will be seen by comparing the above rates with the foreign rates that they are much lower both for long and short hauls. The foreign rate for a 12-gallon can, 10 miles, is 16 cents per can, while the rate, as shown above, for 13 miles is only 7 cents per 100 pounds, or about a 12-gallon can. For 100 miles, the foreign rate for a 12-gallon can is 36 cents, and for 175 miles 52 cents, while the domestic rate is only 30 and 39 cents, respectively, for a can of the same capacity.

A short statement showing the foreign rates for certain distances in comparison with the domestic rates may be of interest:

Foreign rate, can of 12 gallons, per can.		Domestic rate per 100 pounds, or a can of 12 gallons, per can.	
Miles.	Cents.	Miles.	Cents.
10	16	13	7
25	18	26	9
40	20	40	12
50	26	51	17
75	30	74	22
100	36	100	30
125	42	133	34
150	48	145	36
175	52	178	39

The transportation of milk over the Fitchburg Railroad to Boston is done by special contracts. In response to a letter of inquiry the general freight agent says:

We have no published tariff applicable to this traffic, all the business being done by special contracts. The business over this road is done by two contractors, one running three cars to Boston as follows:

From Littleton, 31 miles; Hudson, 34, and Concord Junction 22 miles, with the privilege of carrying 900 8-quart cans per day per car, at a charge of $14,000 per year. The other party runs 1 car from Leominster to Boston, 45 miles, and 1 from Greenville, N. H., to Ayer, 23 miles, at a charge of $9,000 per year, with the privilege of carrying the same quantity of milk as in the other case.

The Baltimore and Ohio Railroad Company furnishes rates on milk to Baltimore as follows:

	Per gallon.
For 30 miles and under	$0.02
Between 30 and 40 miles	.02½
Over 43 miles	.03

The rates on milk in the West around Chicago are not as high generally as they are in the East, as compared with the distance transported. A few statements showing the rates to Chicago and Saint Paul are here presented:

Chicago, Burlington and Quincy Railroad Company.

[In cents per can.]

To Chicago from—	Miles.	Eight-gallon cans.	Four-gallon cans.
Riverside	11	15	10
La Grange	14.5	15	10
Downer's Grove	21	15	10
Lacton	22	15	10
Lisle	24	15	10
Naperville	29	15	10
Eola	33	15	10
Aurora	37	20	10
Montgomery	40	20	10
Oswego	43	20	10
Bristoe	46	20	10
Yorkville	49	20	10
Fox	52	20	10

Chicago and Alton Railroad Company.

[In cents per can.]

To Chicago from—	Four-gallon cans.	Eight-gallon cans.	Ten-gallon cans.
Summit	10.25	13.25	16.25
Mount Forest	10.5	13.5	16.5
Willow Springs	10.75	13.75	16.75
Lemont	11.5	14.5	17.5
Romeo	12	15	18
Lockport	12.25	15.25	18.25
Joliet	12.75	15.75	18.75

Chicago, Milwaukee and Saint Paul Railway.

[In cents per can.]

Applying between all stations for distances of—	Ten-gallon cans or under.	Eleven to twenty gallon cans.
25 miles and under	20	30
26 miles and not over 59 miles	30	40
60 miles and not over 100 miles	40	50

Chicago and Northwestern Railway.

[In cents per can.]

To Chicago from—	Eight-gallon cans.	Ten-gallon cans.
Galena Division Air Line.		
Oak Park	15	19
Wheaton	15.5	19.5
Geneva	15.8	19.8
Aurora	16	20
Elburn	16.5	20.5
Maple Park	17	21
Cortland	17.5	21.5
De Kalb	18	22
Malta	19	23
Creston	20	24
Rochelle	20.5	24.5
Flag	21	25
Ashton	22	26
Franklin Grove	23	27
Nachusa	24	28
Freeport Line.		
Wayne	15.8	19.8
Elgin	16	20
Gilberts	17	21
Marengo	19	23
Belvidere	21	25
Cherry Valley	22	26
Fox River Line.		
Dundee	16.6	20.6
Algonquin	17.3	21.3
McHenry	19	23
Fox River Line—Continued.		
Ringwood	20	24
Richmond	21	25
Lake Geneva	22	26
Wisconsin Division.		
Irving Park	14.8	18.8
Jefferson Park	15	19
Arlington Heights	15.5	19.5
Cary	15.8	19.8
Crystal Lake	16	20
Woodstock	17	21
Hartland	17.5	21.5
Harvard Junction	18	22
Lawrence	19	23
Sharon	20	24
Clinton Junction	21	25
Chicago and Milwaukee Line.		
Ravenswood	14.5	18.5
Rose Hill	14.9	18.9
Evanston	15.3	19.3
Winnetka	15.5	19.5
Lake Forest	15.8	19.8
Waukegan	16	20
Kenosha	17	21
Racine	18	22
County Line	20	24
Oak Creek	21	25

Chicago, Saint Paul, Minneapolis and Omaha Railway.

[In cents per can.]

To Saint Paul and Minneapolis from—	Five-gallon cans.	Eight-gallon cans.	Ten-gallon cans.
Jordan	10	16	20
Belle Plaine	11	17.6	22
East Henderson	12	19.2	24
Le Sueur	12.5	20	25
Saint Peter	13.5	21.6	27
Mankato	14.5	23.2	29
Lake Crystal	15	24	30
Saint James	16	25	32
Dundee	16.5	26.4	33
Adrian	17	27.2	34
Beaver Creek	17.5	28	35
Lake Elmo	10	16	20
Stillwater	10	16	20
River Falls	12	19.2	24
Hersey	13	20.8	26
Rusk	14	22.4	28
Eau Claire	15	24	30
Fairchild	16.5	26.4	33
Wrights	17	27.2	34

The general freight agent of the Chicago, Rock Island and Pacific Railway Company writes, relative to milk rates over that road to Chicago, as follows:

We publish no tariff on this commodity. Agents are furnished with milk tickets, which they sell the same as they do passenger tickets. Our charge is uniformly 18 cents for 10-gallon cans and 15 cents for 8-gallon cans. These rates cover transportation not exceeding 40 miles.

RAILROAD CONSTRUCTION IN 1887.

During the latter half of the past year many estimates were made of the number of miles of railroad that would be constructed during the year 1887. These estimates varied greatly, ranging from 9,000 to 12,000 miles, but none were seen higher than 12,000. A detailed statement, published in the Railway Age, of Chicago, December 30, 1887, shows that 364 lines, representing 42 States and Territories, constructed an aggregate of 12,724 miles. While these figures may be changed somewhat, they are no doubt as close approximations as can be obtained at this date, and are sufficient to show the immense railway growth, especially in those States whose resources are as yet undeveloped. The number of miles constructed and not yet reported will no doubt swell the aggregate to nearly, if not quite, 13,000 miles. The statement showing the mileage by States is as follows:

Number of lines and miles of tracks laid during the year 1887, *exclusive of sidings and main-line track relaid.*

States.	Lines.	Miles.	States.	Lines.	Miles.
Maine	2	31	Wisconsin	11	363
New Hampshire	1	23	Minnesota	9	196
Massachusetts	5	55	Dakota	17	760
New York	6	97	Iowa	10	352
New Jersey	2	15	Nebraska	17	1,101
Pennsylvania	13	125	Wyoming	3	133
Maryland	1	18	Montana	7	616
West Virginia	3	53	Kansas	44	2,070
Virginia	4	64	Missouri	16	554
North Carolina	10	184	Indian Territory	5	499
South Carolina	7	104	Arkansas	8	153
Georgia	8	231	Texas	19	1,055
Florida	10	193	Colorado	9	818
Alabama	15	515	New Mexico	1	4
Mississippi	5	99	California	14	358
Louisiana	4	65	Idaho	2	54
Tennessee	10	68	Utah	1	6
Kentucky	8	168	Arizona	2	70
Ohio	14	155	Oregon	4	48
Michigan	13	700	Washington	3	108
Indiana	9	115			
Illinois	12	328	Total	364	12,724

The above figures show that the year 1887 was one of unprecedented activity and far surpasses in extent of mileage any one year of railway construction in this or any other country. The greatest number of miles constructed in any previous year was 11,568 in 1882, which was thought would not again be equaled; but the above figures, 12,724, although incomplete, show an increase of 1,156 miles, or 10 per cent., over 1882, and should these figures be increased to 13,000 miles, which is not at all improbable, the increase would be 1,432 miles, or 12.4 per cent.

Nearly three-fourths of the railways constructed during 1887 were in the Western States. Dividing the country into two parts by the Mississippi River, we have 9,383 miles, or 73.7 per cent. of the whole, on the west, and 3,341 miles, or 26.3 per cent., on the east. Of the amount constructed west of the Mississippi River, seven States and Territories claim 6,934 miles, or 73.9 per cent., and are in order as follows: Kansas, 2,070; Nebraska, 1,101; Texas, 1,015; Colorado, 818; Dakota, 760; Montana, 616; and Missouri, 554 miles.

There are five States which show no increase of construction, viz, Vermont, Connecticut, Rhode Island, Delaware, and Nevada.

Poor's Manual of Railroads for 1887 gives the railway mileage of the United States at the close of 1886 as 137,986 miles. By assuming that the mileage for 1887 will approximate 13,000 miles we have the immense aggregate of 150,986 miles, which is three or four times greater than any other country in the world. A brief comparison of the annual increase of railway mileage during the past ten years may be of interest:

Miles of railroad constructed each year from 1878 *to* 1887, *inclusive.*

Years.	Miles.	Years.	Miles.
1878	2,629	1883	6,741
1879	4,746	1884	3,825
1880	6,876	1885	3,608
1881	9,796	1886	9,000
1882	11,568	1887	*13,000

* Estimated.

CONCLUSION.

The facilities for statistical work have been increased during the year. The mission of the Statistician, in the spring of 1887, for the investigation of statistical methods of European governments, and the exchange of official publications, and procurement of printed data illustrating the rural economy of European nations, resulted in obtaining valuable information concerning the organization, appliances, purposes, and results of statistical offices of the principal countries, and a collection of printed reports which constitute an invaluable addition to the reference library of the office.

The Statistician had time only for a hurried investigation of the systems of Italy, France, Austria, Germany, and Great Britain. The representative of the Department in London, Deputy Consul-General Edmund J. Moffat, did a similar duty in connection with the Holland and Belgium service.

The Statistician desires to recognize gratefully the courteous and willing assistance received from officials everywhere in his efforts to learn the aim, scope, and methods of each official organization for statistical work. This effort was the more difficult and complicated from the diversity of organization and function—such divergence and lack of unity as exists in the scattered statistical bureaus and divisions of different Departments of our Government. The ministers of the United States and the consul-generals located at Rome, Paris, Vienna, Berlin, Brussels, and London rendered with alacrity any needed aid in facilitating introduction to officials and promoting the efficiency of the investigation. Where all were courteous it may seem invidious to particularize, but it may be proper especially to recognize the assistance and kindness of Statisticians Luigi Bodio, director-general of Italian statistics, and N. Miraglia, director-general of agriculture, Rome, Italy; Alfred de Foville, chief of the bureau of statistics of the ministry of finance, and M. Tisserand, director of agriculture, Paris; Robert Giffen and Alfred Edward Bateman, of the board of trade, London; and Patrick George Craigie,

secretary of the chambers of agriculture, London; Von E. Blenck, director of the imperial bureau of statistics, Berlin; Dr. Karl Theodor von Inama-Sternegg, chief of the imperial statistical commission, Vienna. The late lamented vice-president of the International Institute, whose death has been recently announced, Dr. Franz Xavier von Neumann-Spallart, of the Imperial University and other institutions of Austria, was also assiduous in his efforts to facilitate the investigation in Vienna.

The information thus obtained, and the publications filed for reference, will prove of great advantage in international comparisons. The work of the International Institute, in collecting and co-ordinating data for uniform international statements, is continued *ad interim* through committees in various specific lines of investigation and must result in a great advantage to agricultural, commercial, and scientific education throughout the world. In this work the United States should accept its full quota of effort and reap its fair proportion of advantage.

J. R. DODGE,
Statistician.

Hon. NORMAN J. COLMAN,
Commissioner.

REPORT OF THE CHIEF OF FORESTRY DIVISION.

SIR: The subject-matter which has been prepared for this report has been found to be of such special interest that it has appeared advisable to issue the report as a separate publication, and it remains for me here only to refer to one phase of the subject therein presented, which is not only of general interest but at present the most important forestry question of national concern.

It has been apparent for some years that the nation or the Government should in some way interest itself specially in the proper development and maintenance of one of her choicest natural resources, the once so-called "inexhaustible" forest wealth.

The reasons for such special interest in this class of national property are fourfold.

It has become evident, in spite of the enormous supplies which seemed to be available, that our natural forests are being rapidly reduced, both by an increased demand and by wasteful practices; and it is now safe to say that the annual consumption of wood and wood products is at least double the amount reproduced on our present forest area. The forest, under proper management, is capable of furnishing continuous crops, and therefore, as a source of constant supply, demands national consideration.

It has become evident that with the unrestrained scourge of fire and the destruction by herding and other malpractices now prevalent, and in the absence of all rational forest management, not only is the remaining forest deteriorated in material value, but large tracts of land are converted into absolute deserts or useless barrens. A sound land policy, therefore, demands that the nation should give earnest attention to forest management.

It has become evident that we are not to escape the consequences of disturbing the even distribution of water-flow by forest devastation and denudation of mountains and hills which have been experienced in other parts of the world, and which have reduced fertile lands to barrenness, prosperous communities to poverty.

Regard, therefore, for the future welfare of the several communities which in their aggregate represent the nation calls for a rational forest policy, a proper utilization, a proper distribution, and a proper management of the natural forest.

Lastly, if the nation as such is interested in the proper development of the rich agricultural lands of the plains and prairies, it must be interested also—in that part of its domain at least—in forest planting as a means of ameliorating climatic conditions and making the region more habitable.

This fourfold aspect of the forestry problem presents itself for consideration to every nation, and nation after nation has recognized its importance and acted accordingly. With the exception of England, which by its insular position is exceptionally situated, all the

European governments have properly-equipped forest administrations. Russia, the English colonies in Asia and Australia, Japan, and even China have recognized the necessity for action in this direction, and have acted. The United States alone, among the civilized nations, has as yet failed to perceive the wide bearing which a proper forest policy has upon the material and moral development of a country.

While it is gratifying to note that interest in the forestry problem is growing in every section; while the discussions on the same have assumed a more precise and practical character; while in some of the States a dawning of what the forestry question really means is observable, yet we can not say that the importance of the question is at present adequately appreciated by the mass of our people, or even by those directly interested; nor can we say that there is a disposition on the part of those who shape the future of this country to give even an earnest consideration to this great interest, which, to be sure, affects the future rather more than the present.

Let it not be overlooked that the State, represented in its legislature, is not only the representative of the interests of the community as against those of the individual, but also a representative of future interests as against those of the present; let us not forget, too, that the forest is a kind of trust, of which only the usufruct belongs to the present, and that to draw upon its capital is a perversion of the trust which can only be excused by direst necessity. Every civilized country has found by severe experiences that private interest is not sufficient to protect the forest property of a nation and that the State or the community must exercise a supervision of forest management, in those regions at least where the forest subserves other functions than those of merely supplying material.

It is not the forest that is valuable and would appear worth his protection to the individual, but the timber which the forest yields. As soon as that is gone the value and the interest for the individual is gone. The individual man plans for his pocket and his own short life; only the collective and protracted life of the State is fitted to deal with the protracted life of the forest and with interests not measured by pecuniary considerations alone. The interest which the community has in the forest is transcendent; the continuation and protection of the forest cover is of significance to the continued welfare of the community, especially in the mountain regions, and the mountain forests will therefore be in safer hands with the community at large—with the State.

This brings us to the question that I wish to discuss in the few pages allotted to me in this report:

WHAT IS THE FIRST DUTY OF THE GENERAL GOVERNMENT IN REGARD TO THE FORESTRY QUESTION?

The answer will be apparent to everybody after the presentation of the following facts:

The General Government still holds, as an individual national property, a forest area the extent of which is unknown, but may be estimated between 50,000,000 and 70,000,000 acres. The bulk of these lands is to be found on the rugged mountain sides and crests of the Western ranges, notably the Rocky Mountain, Cascade, Sierra Nevada, and Pacific coast ranges, mostly land not fit for agricultural use. The agricultural valleys at the foot of these ranges are not only destitute of timber, but they are dependent for their agricultural

productions upon irrigation, the water for which is derived from the mountain streams and more rarely from artesian wells, both of which sources are fed by the rains and snows which fall upon the forest-covered mountain sides and gradually find their way to the plain below. As has been repeatedly stated and explained elsewhere, and proved not only by experience but by actual experiment on a large scale,* the forest cover regulates and beneficially influences the rapidity with which these precipitations are carried to the plain for utilization on agricultural lands.

After entire cantons had been impoverished by the action of torrents, due to deforestation, the French Government found it necessary to interfere, or rather, interference coming too late, to assume or aid in the work of reforestation. The construction of vast reservoirs to retain the surplus waters in flood time, the construction of stupendous dams, and the embankment of river courses were first suggested as remedies for the evil, just as our ambitious engineers are now proposing. But these were soon found not only to be impracticably costly but to create new dangers, perhaps greater than the old, since the mountain reservoir might burst at any time and the embanked river was certain to rise to a dangerous level above the surrounding plain. The wiser plan of reforestation was finally resorted to, with results which have now proved the wisdom of that measure. Austria and Italy, under similar conditions, after sending commissions to France to study the effects of reforestation, have begun similar work. Since the year 1860, the French Government acting in co-operation with the local communities, it is estimated that over 250,000 acres of mountain lands have been reforested, at a cost of

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* There has been of late much discussion as to whether or not there exists any relation between forest cover and rain-fall, and records of meteorological data have been brought forward to show that in Ohio, for instance, deforestation, if anything, had the effect of increasing rain-fall, while no increase of rain-fall has been noticeable in Kansas since tree-planting began there. How little value is to be attached to the use of the records on hand for showing any interrelation between tree-growth and rain-fall may be inferred at once from the fact that these same records can be and have been used to prove exactly the opposite influences, showing, without reference to the causes, that an increased precipitation in the Western regions is observable. In fact, outside of the special observations which have been made in Germany, and less satisfactorily in France, there are no data at hand for definitely proving either the existence or the absence of forest influences on the humidity of the atmosphere. This influence, as probably most forest influences, is of local character; the extent to which it is felt is limited, and can be measured only by special records for each locality.

It is not unreasonable to believe that the influence of a forest area upon rain-fall may be exactly the opposite from beneficial to the plain beyond, and yet this does not alter the proposition that an influence exists. If, for instance, a large uninterrupted forest area were lying towards the side of the rain-bringing winds, it is possible that the condensation to which the cooler and relatively moister air above the forest would give rise might drain the clouds before they had passed on to the plain, and thus a partial removal of the forest growth might be promotive of moisture on the plain. The reasoning that a large, dense forest cover of the soil, sufficiently large and dense to create a considerable difference of temperature and with it of moisture in its air strata, should exert an influence upon precipitation seems to be sound; but while the actual existence of such influence seems to have been locally observed it is not, as a general proposition, proved or disproved.

That the transplanting in Kansas should have been sufficient t create such differences of atmospheric conditions as are necessary to exert an influence upon rain clouds is at least doubtful, and the reasons above given for the increase of rain-fall, if any, seem more tenable.

Meanwhile, the well-proved mechanical influences of forest-growth on the even distribution of the fallen rain through the year in springs, brooks, and rivers outweighs all other considerations for practical purposes.

$30,000,000, the state paying one-half. In addition, about 200,000 acres of sand dunes have been brought under forest cover, and 375 miles of torrential streams have been secured.

It is estimated that $34,000,000 more will have to be expended before all the lands devastated by forest destruction will be recuperated. The total appropriation for the forestry department of France for the year 1887 was $5,000,000, of which nearly $700,000 was "for the conservation and restoration of mountain districts by reforesting and resodding."

The forest areas which are still in the hands of our General Government are mostly situated under similar conditions as these areas of our sister republic, France; by their position they assume similar significance and ought to receive the same consideration from the community as those properties which, like air, water, roads, etc., are administered with a view to the common welfare.

The present condition of this forest area on the Rocky Mountain ranges has been carefully ascertained and is described in a special report, prepared in the Forestry Division and now in the hands of the printer.

By reference to the accompanying map, which exhibits the forest areas and main irrigation ditches in the Rocky Mountain States and Territories (excepting Utah), it will be found that the areas noted as covered with timber, compared with the timberless areas, are extremely small and confined mostly to the higher mountain ranges. This report will also show that much of the area is but thinly covered with trees and much of it culled of its best timber and by wasteful practices and fire deteriorated in material value.

The irrigation systems which, as stated, are dependent upon the mountain streams are only in their infancy, if compared with the large areas which, with the aid of irrigation, are capable of being utilized for agriculture. Almost the same conditions exist in southern California, except that the forest is of less account and what remains in worse condition, while on the northern Pacific coast most valuable tracts of heavy timber are rapidly passing from Government into the hands of lumbermen, but more often of speculators and large syndicates with foreign capital. Altogether, the timber in the region west of the prairie States can not be said to occupy lands needed or even fit for agricultural purposes, but covers, as already noted, the broken ridges, hills, and mountains, these forests in the main being more valuable on account of their position than of their material value, except on the northwestern coast.

It should also be stated that the forest growth in this region consists almost entirely of coniferous trees, which are propagated by seed alone, and that the climate is in many parts not favorable to the germination of seeds nor to the life of seedlings, except under proper protection.

What disposition is being made of this valuable property of the nation, and what means are employed to guard and protect it against deterioration and waste?

There are five ways in which a citizen may acquire either the land or the timber on it:

(1) In California, and on the Pacific slope generally, any bona-fide settler can secure as much as 160 acres at $2.50 per acre, a price from ten to thirty times less than the true value. The condition of the law to be fulfilled is that he shall hold this property "for his own use." But it is well known that most if not all the purchases have

MAP
OF THE
ROCKY MOUNTAIN REGION
SHOWING THE APPROXIMATE LOCATION AND EXTENT OF FOREST AREAS AND IRRIGATION DITCHES IN 1885.
COMPILED FROM COUNTY RETURNS
BY
COL. E. T. ENSIGN, Forestry Agent of the Department of Agriculture.
REFERENCES:
Forest Lands shown in green,
Main Irrigating Canals shown in red lines.
PHOTO LITH BY A. HOEN & CO. BALTIMORE, MD.
MONTANA
IDAHO
WYOMING
UTAH
COLORADO
ARIZONA
NEW MEXICO
NEBRASKA
DAKOTA
GROS VENTRE, PIEGAN, BLOOD, BLACK FEET AND RIVER CROW INDIAN RESERVATION
CROW INDIAN RESERVATION
SIOUX INDIAN
SWEET WATER
UINTAH INDIAN RESERVATION
UNCOMPAHGRE UTE INDIAN RESERVATION
MOQUI IND. RESER.
YELLOWSTONE
CUSTER
DAWSON
OWYHEE
ONEIDA
BINGHAM
FREMONT
CROOK
SAN JUAN
RIO ARRIBA
BENT
LAS ANIMAS
GREAT SALT LAKE
GREAT SALT LAKE DESERT
CACTUS PLAIN
PLAINS
STAKED

been made with the purpose of relinquishing the land as soon as possible to some large lumbering corporation or syndicate, which, in fact, has often paid men to perjure themselves in taking up such lands.

(2) In the Southern States it has been possible to buy Government timber lands at $1.25 per acre. Most of these have probably been disposed of and are held by speculators and lumbermen and not by the agriculturists, whom it was avowed this disposition of land was to benefit.

(3) Every land-grant railroad, in addition to its share of the land grant of 75,000,000 acres and the right of way, is permitted to cut timber "for first construction, adjacent to the line of its road." But the railroads do not construe "construction" and "adjacent" exactly in the sense in which the lawgivers did, and they have cut wherever, whenever, and for whatever purpose they chose.

(4) Those who take up a homestead or pre-emption claim upon timber land are also given the right to clear as much timber as is necessary for the development of their claim and improvements before they have acquired title. But it is known that most settlers on such lands do not exert themselves to procure the title after they have got the timber off.

(5) Lastly, any resident citizen may cut all the timber he needs for mining and domestic purposes upon lands which are designated as "mineral lands," a term which will defy definition even by an expert.

Without going into a detailed account of the history which relates to the disposition of public lands and the various ways in which attempts were made to protect the forest property from spoliation, it can be stated as a result of an examination of the reports of the General Land Office that at all times these attempts at protection have been futile, from the fact that no adequate means were allowed for this purpose.

That the timber on the public domain had a special value and also that it needed, like all movable property, to be looked after and protected, was recognized by the Act of March 2, 1831, for the care and custody of public timber land, which established a system of agencies under the supervision of the Solicitor of the Treasury. When, in 1854, the management of the timber interest was transferred to the General Land Office, and the registers and receivers were expected to act as timber agents without additional pay, an exceedingly liberal construction as to the rights of taking timber, and naturally a lax enforcement of any laws, prevailed until 1877. In 1878 a special appropriation of $25,000 was made "to meet the expenses of suppressing depredations upon timber on the public lands."

In fact, until 1876 all the action taken against timber stealing, when discovered, was the collection of stumpage; and an attempt was made to levy, in the discretion of the receivers, a regular quarterly tax from saw-mill men, without sanction of the law. From the year 1872 annual appropriations had been made for this service, amounting in the aggregate to $48,000 ($45,624.76 expended).

In 1877 the Commissioner of the Land Office instituted a service of special agents to prevent or detect timber trespass, and this system has prevailed ever since. As to the efficiency of the present methods of protection no words need to be added to the following table, which exhibits the results of the administration of this public property during the last seven years, showing that the depredations which were discovered upon the public timber land amounted to over

$5,000,000 annually in the average, and that out of this but little more could be recovered than enough to pay the salaries of the few agents employed ostensibly for the protection of this property:

Year.	Value of timber reported stolen.	Amount recovered.	Appropriation for protective service.	Number of agents employed in the aggregate.
1881	$891,888	$41,680	$40,000	17
1882	2,044,278	77,365	40,000	31
1883	8,144,658	27,741	75,000	25
1884	7,289,854	52,108	75,000	26
1885	2,862,530	49,451	75,000	23
1886	9,339,679	101,086	75,000	21
1887	6,146,935	128,642	75,000	26
Total	36,719,935	478,073	455,000	24

During the same time the protests of the Commissioners of the Land Office, appearing in the annual reports, stated that it was impossible with the appropriations and forces at command to stay the wanton, wholesale devastation and destruction of the public timber; but their protestations have remained unheeded.

Every one of these reports deals lengthily and in detail with the depredations and devastation by ax and fire, the deficiency of funds with which to counteract them, with the feeling of the law-abiding citizens in regard to them, the necessity of preserving at least the forests at the headwaters of streams, and with the proposed changes of administration.

The report for 1887 contains a chapter especially illustrative of the manner in which a small minority, unchecked, defrauds the nation which every citizen who feels himself a part of this great Government "of the people, by the people, for the people" will do well to ponder over.

Such is the moral aspect of our present condition in regard to our public timber lands and the reasons for a change in our forest policy.

Under the present conditions not only is it made difficult for the resident population to supply itself with the needed timber in an honest way, but the danger of doing so in opposition to the law entails an enormous and needless waste. Acres of timber are felled in anticipation of a possible use, but are commonly left to rot on the ground because their haulage may become too risky or the depredator finds it difficult to dispose of the timber; and consequently it furnishes food to the ever-recurring annual fires, which destroy also not acres but miles of standing forest, and no legal disposition of the burned timber can be made. It is well attested by men acquainted with the manner of timber-cutting on the Pacific slope that those who may cut timber legally on mineral lands, homesteads, or timber entries have no interest except to satisfy a present need, for they cut timber regardless alike of future supply, proper management, or of favorable forest conditions, utilizing only that part of the tree which is readily available and leaving the remainder to rot or burn. Local supplies are waning in many parts of this region, but no intelligent and systematic management, such as would insure a full utilization and continuity of the timber, is encouraged under the existing laws and regulations. While, in view of the needs of local mining operations, this is an undesirable prospect, especially to mines yielding only low-grade ores, which will not allow the burden of heavy charges for the importation of their mining timber, at the same time the

graver consequences of the situation will be readily understood by those who have studied the history of deforestation and forest devastation in southern France, Switzerland, Austria, Spain, Italy, and those far eastern countries which compare somewhat in climatic conditions with the regions in question.

Not only is the forest cover of the mountain crests destroyed when it might have yielded continuous supplies, but at the same time agriculture in the valleys below is first endangered and then made impossible.

The regularity of water supplies is all-important in regions where, as in most of the plains of Montana, Wyoming, Colorado, Utah, New Mexico, and southern California, agriculture is dependent upon the aid of irrigation. This is being interfered with when the mountain sides are laid bare, allowing the rains to run off as from a roof and the snows to melt and the water to pour down in torrents at a time when more than enough water is on hand, and when the husbanding of the supplies for a later season is highly desirable.

Other consequences, such as an increase of snow-slides and land-slides, the washing of débris into the valleys, have begun to make themselves felt, and it can be only a question of time when we must reach such a state of things as was brought about in the mountain districts of France, Switzerland, and the Tyrol.

During the summer of 1887 the writer undertook, at his own expense, a journey through the Rocky Mountains in order to become acquainted with the region which, as will have appeared, must be of the greatest immediate interest to the National Government with reference to forestry work. As the journey was undertaken in connection with meetings of the American Institute of Mining Engineers, an excellent opportunity was afforded to meet and ascertain the views of one of the most intelligent classes of the population—those engaged in mining. It was admitted everywhere that the present conditions of administration have become insufferable, and that the practical forestry work of the Government should first of all be directed to the protection and proper administration of its timber lands.

The desirable legislation for such action on the part of the Government, outlined in my last year's report, has been more fully formulated after the personal inspection of local conditions afforded by my journey, and is embodied in a bill providing an administration by which the Government forests may not only be protected against fraudulent practices and against the ever-raging forest fires, but which also recognizes the local needs for wood and lumber and provides for their sure, honest, and ready supply.

The essential features of this bill, which has been submitted to Congress through the agency of the American Forestry Congress, are as follows:

The withdrawal from sale or other disposal of all woodlands still in the hands of the Government and the classification of the same into three classes is provided for.

The lands found to be of agricultural value, but wholly or partially timbered, are to be open to entry under the homestead or other laws, but an appraised value for the timber shall be paid by the settler, excepting for the timber on 5 acres, which he may hold under a "settler's license," without any payment other than a nominal license fee of $2. The timbered lands on the headwaters of streams, or other timber lands unfit for agriculture, shall not be sold, but the timber on the same may be disposed of under a system of licenses.

The sections of the bill providing for these licenses are perhaps the most important part of the proposed legislation, and as they are novel in their form are here given in full:

The disposal of timber for domestic purposes shall be made by means of licenses, as follows, namely:

(1) A prospector's license shall be granted to any applicant by the local (district) inspector upon the payment of two dollars. Such license shall confer the right to prospect for minerals upon land falling under the provisions of this act, and also the right to cut without waste and under the general regulations of the forestry board and the supervision of the rangers, timber for the first construction of shanties, prospecting shafts, and other necessary structures from the territories nearest to the prospector's claim or claims. Such license shall be good only for the district in which it is taken out, and shall end at the expiration of one year from the time of its issue, or whenever, sooner than that, the claim is perfected or the prospecting is abandoned.

(2) A settler's license shall be granted to any bona-fide settler having no timber on his claim by the local (district) inspector upon the payment of two dollars. Such license shall confer the right, for one year, to cut for the licensee's own use only and for domestic purposes timber, fuel, and fence material, without waste and under the general regulations of the forestry board, upon an area of five acres which the licensee may designate near his settlement.

(3) A timber license shall be granted to any bona-fide settler or mine operator or manufacturer, for the purpose of allowing him to supply himself or others with timber, fence material, or fuel, upon the payment of a license fee of five dollars and the further payment before beginning to cut any timber of a sum equal to one dollar for each and every acre embraced in his license, and, in addition, a stumpage of not less than one cent per stump actual count, before the removal of the timber. Such license shall be granted for one year and shall confer the right to cut the timber on not less than forty nor more than eighty acres, the same to be selected by the applicant and the selection to be approved by the local officer.

That all licenses provided for as heretofore stated shall be in printed forms, and shall be issued, upon an order from the district inspector, by the receivers of public money upon the payment of the license fee. Licenses shall be numbered in succession, as applications for them are made, and priority of application shall determine the order in which they are granted. The district inspector shall receive applications for license on certain days of each week, to be published and made known by them. They shall keep open books, in which shall be recorded in proper order applications for license and the action taken upon them, with the names and residence or post-office address of the applicants. The inspector shall also notify the rangers of each license granted in their ranges, and the rangers shall be required to aid licensees in locating their claims. No unused "settler's license" or "timber license" shall be renewed unless good cause is shown for its not having been previously used, nor shall any license be granted to any person who in the use of a previous license has not complied with the regulations of the forestry board. No license of any kind shall be transferred from one company to another and continue to be valid unless the transfer of the same is authorized by the forestry board.

That the timber on lands of the first class which is not needed for mining or agricultural development in the neighborhood shall be disposed of to lumbermen or others, as it may be applied for under a "lumberman's license" in quantities not less in amount than that standing or being on one section nor more than that being on twenty-five contiguous sections. Such license shall be granted, upon the payment of a fee of twenty-five dollars, by the Commissioner of Forests with the approval of the Secretary of the Interior, under the conditions stipulated in the act, and shall confer the right to cut timber and sell the same from as many sections or acres as have been located and paid for. The licensee shall also pay one dollar per acre for the whole number of acres covered by his license before he may begin operations and not later than six months after the granting of said license. And a further charge of not less than one cent per cubic foot shall be paid by the licensee after the timber has been cut and before the same is moved. Such license shall be good for two years, and in all cases in which not more than ten sections of timber are embraced in the license it shall not be renewed more than once for a longer term than two years. Where the license embraces more than ten sections of timber the same rule shall apply in regard to its renewal as in the case of licenses for a less amount of timber, except that for every five sections above ten embraced in the license there may be a renewal of the license for one additional year. No licensee shall be authorized to apply for or take out a second "lumberman's license" until he shall have cut and disposed of three-fourths of the timber to which he is entitled by the license previously given.

That all applications for "lumberman's license" are to be made to the Commissioner of Forests, and must be accompanied by a statement of the location and approximate amount of the timber sought by the applicant, together with a certificate of the local forest inspector to the effect that the lands on which such timber is situated are of the first class and not covered by any of the local licenses as provided in the act, nor presumably needed for such within a reasonable time. Such applications shall be considered in the months of August and September only, and no license shall be granted before at least three months have expired from the date of application and the same has been advertised three times in three local papers, if there be so many, of the district in which the licensee intends to locate. If the same location is sought by more than one applicant priority of application shall not rule as to applications made in the same month, but the application for the smallest location shall in such case receive first consideration. And wherever a survey of the location is necessary the applicant shall pay half of the expense of such survey, and whenever the licensee begins operations upon his location he must notify the local forest inspector, and all cutting and disposal of the timber and other forest products shall be done under the supervision of the local inspector and in accordance with such regulations as the Commissioner of Forests shall prescribe.

To insure a proper administration of such a law, to prevent waste and loss by fires, and to establish the nucleus for the future forestry system of this great nation which we must ultimately adopt, a new bureau in the Department of the Interior is proposed, with a forest commissioner and four assistant commissioners, acting as a forestry board. A division into districts of proper size of the forest lands and forest reserves remaining under the control of the forestry board, and a thorough organization of a local service with forest inspectors and rangers, is also provided.

This is no doubt a thorough-going reform of the present settlement and disposition laws, which the Public Lands Commission of 1883 has characterized as "the cancers that destroy the public timber lands."

None but such a thorough organization can be expected to guard the national property, of which under the present neglect the nation is annually robbed to the extent of from $5,000,000 to $10,000,000, not counting the damage done by fires, the passing of timber lands by fraud into the hands of speculators, and the amount of timber which is legally obtained by railroad companies and others.

But, as has been stated repeatedly, the forest cover in the localities in which the bulk of the public timber lands is situated, notably on the Rocky Mountains and the Pacific slopes, subserve a function which makes its material value of only secondary importance. It has become already evident that the denudation of mountain sides in the region under consideration has impaired the regularity of water-flow, upon which irrigation in the arid valleys below depends.

Preserved in continuous reproductivity, the natural forest cover presents better and cheaper water reservoirs than the artificial structures which are already talked about and for which millions of dollars will be asked by the irrigators and ambitious engineers.

The interest of the nation, therefore, in properly administering this property reaches beyond that of any material advantage.

And certainly in these mountain forests, in this legislation for their proper administration, lies the *immediate national interest in forestry*.

The Forestry Division, without forests, without means and opportunities to engage in active, practical forestry work, can do but little good, except by furnishing information which may guide the legislator or the forest manager, the planter or the consumer of wood, and by bringing the influence of the Department to bear in modifying the existing methods of treating the forests.

To satisfy the demands of these various interests a large number

of subjects claims the attention of him who proposes to furnish such information, so that it becomes difficult to determine which interest should claim foremost attention.

With the increasing need of rational forestry a closer study of all matters pertaining to it will become necessary, and to aid the student of forestry as well as to furnish a basis for the work of the Division, a system has been devised and, in the report, illustrated with copious examples, showing the manifold disciplines which must engage the attention of the student of forestry. As a presentation of this system will enable the general reader to form an idea of what forestry really is, space is here given to a bird's-eye view of the same:

SYSTEM OF FORESTRY INVESTIGATIONS.

A.—SCIENTIFIC BASIS OF FORESTRY.

- I.—*Forest biology.*—(Consideration of the growing crop.)
    1. Timber and forest physiology. Life history of species in their individual and aggregate life.
    2. Forest geography. Floras and their distribution.
    3. Study of forest weeds in their relation to forest growth.
- II.—*Timber physics.*—(Consideration of the grown crop.)
    1. Anatomy of woods.
    2. Chemical physiology of woods.
    3. Physical properties of woods.
    4. Influences determining the physical properties.
    5. Diseases and faults of timber.
- III.—*Soil physics and soil chemistry.*—(Consideration of the conditions for growing a crop.)

B.—ECONOMIC BASIS OF FORESTRY.

- I. *Statistics.*
    1. Forest areas.
    2. Forest products.
    3. By-products.
    4. Prices, trade, substitutes.
- II.—*Technology.*—(Applied timber physics. Needs of wood consumers.)
    1. Methods of harvesting (lumbering) and preparation for market, including improvement of machinery.
    2. Economy in the use of product.
        - *a.* Utilization of waste material.
        - *b.* Methods of increasing the durability of timber.
    3. Special needs of consumers of forest products.
- III. *Forest policy.*—(Determining the relation between forestry and the objects and purposes of the State.)
    1. Forest influences.
        - *a.* Influence on temperature and electricity.
        - *b.* Influence on humidity and rain-fall.
        - *c.* Influence on winds.
        - *d.* Influence on water-flow.
        - *e.* Influence on soil, formation of avalanches, shifting sands, dunes.
        - *f.* Influence on health and fertility (and ethics).
    2. Commercial peculiarities, position of forestry in political economy.
    3. History of forestry.
    4. Forest police, formulation of the rights and duties of the State and of its methods in developing forestry; legislation, State forest administration, education.

C.—PRACTICAL BASIS OF FORESTRY.

- I.—*Origination of the forest.*
    1. Artificial afforestation.
        - *a.* Procurement of seed and other plant material.
        - *b.* Nursery practice.
        - *c.* Choice of kinds for pure and mixed growth.
        - *d.* Methods of preparing soil.
        - *e.* Methods of forest planting.
    2. Natural reforestation.
        - *a.* From seed.
        - *b.* From the stump.

C.—PRACTICAL BASIS OF FORESTRY—Continued.

II.—*Management of the forest and forest regulation.*

1. Methods of improving and accelerating the crop.
   - *a.* Cultivation.
   - *b.* Filling.
   - *c.* Thinning.
   - *d.* Pruning.
   - *e.* Undergrowing.
2. Methods of improving forest conditions.
   - *a.* Road-making and facilities of transportation.
   - *b.* Survey, division into blocks, and booking (describing) area.
   - *c.* Protection against fire, water, shifting sands, climatic influences, insects, cattle, abuse of pasturage, etc.
3. Methods of management.
   - *a.* Timber forest.
   - *b.* Standard coppice.
   - *c.* Coppice.
   - *d.* Method of "selection" and other methods.
4. Forest regulation.
   - *a.* Ascertainment of rate of accretion; methods of determining accretion in mass; value; yield.
   - *b.* Ascertainment of proper rotation and determining yearly or periodical cut.
   - *c.* Regulation of the use of forest by-products.

III.—*Harvest.*

1. Methods of cutting with a view to natural reproduction; progressive fellings.
2. Methods of securing most thorough utilization of product.

Besides the needs of the student of forestry and of the forest planter there remains the necessity of aiding in a general enlightenment of the people regarding the meaning of the forestry movement, for we still expect that the intelligence of the people will bring about those economic reforms for which in the older countries the initiative is taken by the Government. For this reason a considerabel amount of missionary work has been done by the Division during the past year and has entailed upon the writer the preparation of not less than ten addresses upon as many different aspects of the forestry question, given before forestry and horticultural associations, State boards of agriculture and other societies, lectures delivered in various places, the writing of many letters of advice on general and special questions, and of circulars of information, etc. Some of the latter will be found reprinted in the separate annual report, as also other matter of interest to all classes of readers. A special chapter has been devoted to the subject of experimentation, giving in detail the directions in which forestry experiments may be profitably extended by the State agricultural stations, endowed as they are by national appropriations. Another chapter reviews briefly the condition of forestry interests in each of the States and Territories.

It must not be overlooked that the forestry problem is an essentially different one for every section of our country.

In New England and the Northeastern States it involves probably the solution of the questions, what can we do to make the natural forest areas more quickly and more fully productive in the future? how can we best make our waste places valuable by forest growth? and how can we best protect forest property? In the South the question may be, how can we utilize our timber to best advantage without impairing the continuity of the forest as a valuable property? On the prairies, what can we do to secure in the quickest and most permanent manner such forest growth as will bring climatic

REPORT OF THE MICROSCOPIST.

SIR: I have the honor to submit herewith my sixteenth annual report.

Since the publication of my first official bulletin, in 1884, relating to the microscopical methods of detecting butter substitutes, there has been a continued demand for information on this subject from all parts of the United States, extending to Great Britain, France, Germany, etc.

The inquiry for more and fuller information respecting this branch of my division comes from a large number of those more or less interested, professionally, in the classification of animal and vegetable fats as determined by microscopical observations. Farmers, dairymen, inspectors of butter and milk, presidents of boards of health, physicians, chemists, microscopists, and the general public have expressed a deep interest in this subject.

In my first experiments, a notice of which was published in the New York Quarterly Microscopical Journal, 1879, vol. 2, with illustrations, and also in the Scientific American for the same year, I found that the detection of oleomargarine was comparatively easily accomplished with the lower powers of the microscope and plain transmitted light. The material, as then sold, was highly crystalline, and animal tissues, even to minute blood vessels, were found in it. About this time the managers of an oleomargarine factory in Baltimore, Md., supplied me with samples of their oleomargarine, by an examination of which I was able to convince them that their product contained animal tissues and other impurities. They soon devised means to remove these impurities in the process of manufacture. But the object of my labor being rather to detect oleomargarine than to purify it, it became necessary to improve my methods for this purpose, as, by the employment of skilled chemists, the composition became more and more difficult of detection by means of plain transmitted light only. I therefore resorted to polarized light, which enabled me to distinguish the forms of the respective fats found in oleomargarine compounds.

With regard to the differentiation of crystals of butter and fats, as shown under the microscope, great progress has been made during the past year, not only in the methods of determining one fat from another, but also in the production of very superior micro-photographs of them, and still further in the reproduction of these, by newly improved photo-mechanical processes. But no process of reproduction will ever wholly represent the minute structure of the fatty crystals as viewed by the microscope, for reasons obvious to experts.

OTHER INVESTIGATIONS.

During the year I have also made a large collection of Palm and and other fibers, but in consequence of lack of sufficient help and pressing demands for information regarding fats and oils, I have been unable to make any extended investigations in this direction.

Independently of these investigations a large number of examinations have been made for various correspondents throughout the United States, such as of milk and bacon supposed to have been poisoned; adulterations of textile fibers; tests of the fibers of ramie, mulberry, and the century plant as to the texture and purity; the samples having been furnished by parties engaged in the manufacture of machinery for separating fibers from the gum and bark of the plant; improved flour from Ohio; certain investigations for the superintendent of the propagating gardens; water from a condemned pump in the city of Washington, found to be very impure, demonstrating that the action on the part of the board of health had been justifiable; investigation of certain poisonous plants for the Army Medical Museum which were supposed to have caused the death of an inmate of the Soldiers' Home in this city; well water containing animal organisms; a sample of 100 pounds of fat picked up in mid-ocean, at first taken for ambergris, found to be fluorescent under the sulphuric acid test; a new edible mushroom, found in Florida, examined and reported upon. This species is greedily eaten by cats. Examination of spices as to their purity, received from a wholesale firm in Baltimore, Md., and many other investigations of greater or less importance have been made in behalf of the farming and commercial interests.

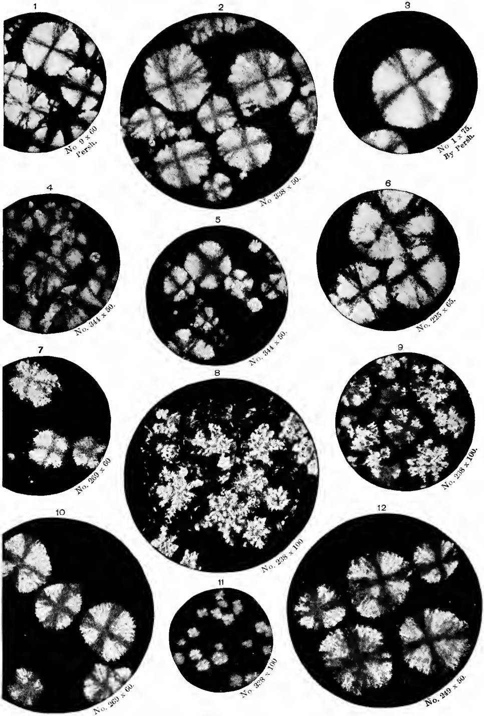
INFLUENCE OF SPECIAL BREEDS.

In the course of these investigations, through the courteous co-operation of breeders and owners of valuable herds of cattle, I have been supplied with samples of butters of registered milch cows of different breeds in various parts of the United States.

My object has been to ascertain whether butter crystals are modified in form, color, etc., by breed, climate, marked changes of feed, or other conditions. These investigations are comparatively limited, yet the practical results have a substantial value, as shown by my large collection of photographs representing the crystals of these butters.

Figs. 1, 2, 3, 4, and 10, Plate 1, represent the general form of the aggregations of crystals obtained from butter of the Shorthorn Durham cow. They are mostly smooth, globose bodies, yielding in a few days secondary crystals of a rosette-like form, which appear first in the center of each globose body. The globose bodies finally dissolve in the oil in which they float. A few secondary crystals are seen in Figs. 1 and 2. Figs. 7 and 9 represent secondary only, which change in time to the highly stellate or tertiary form seen in Figs. 8 and 11. These, in turn, gradually degenerating, become, to all appearances, under low powers, amorphous granules, though in point of fact they are composed of minute spicules very difficult to determine even by high powers of the microscope. Butters of all breeds pass through these changes.

There appears to be a tendency in the butter crystals of Shorthorn and of the cross-breeds, as, for example, Jersey and Shorthorn, to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Persh.
2
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7
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11
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12
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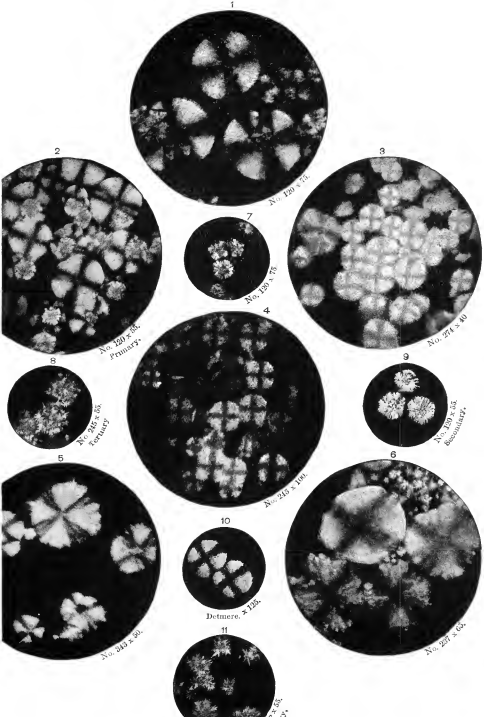
JERSEY.


1
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No. 120 x 55.
Primary.
3
No. 274 x 40
7
No. 120 x 75
4
No. 245 x 100.
8
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Tertiary
9
No. 120 x 55.
Secondary.
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10
Detmere. x 125.
11
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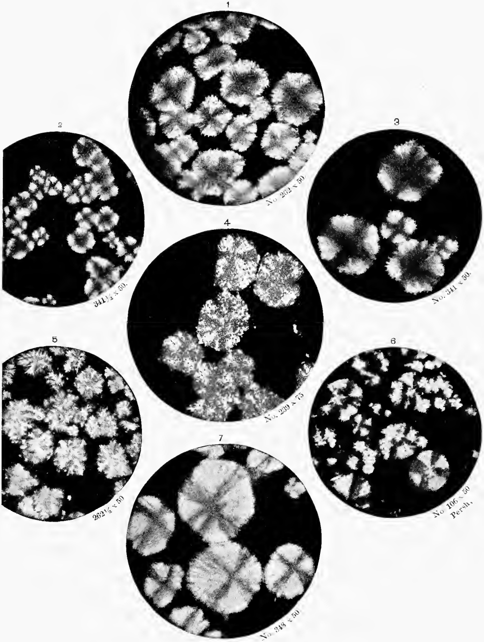
Tertiary,

SHORTHORN.


1
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4
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5
262½ x 50
6
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Persh.
7
No. 348 x 50

HOLSTEIN.

maintain the outline characteristic of their respective forms, as represented in Fig. 6, but crystals of Shorthorn butter are found which exhibit the broken outline, as in Fig. 5, which is more like a Jersey butter crystal.

Fig. 6 represents groups of butter crystals from a cross of Shorthorn with Jersey. The two upper globose bodies are typical of the Shorthorn, while the two lower large bodies exhibit a broken outline somewhat resembling Fig. 5, common to Jersey butter.

Figure 10 is a photograph taken by Professor Detmers, of the Ohio Experiment Station, from butter of thoroughbred Shorthorn milch cows, furnished him by Mr. Chester, of Columbus, Ohio. He informs me that this butter, on being boiled and cooled in the usual manner, presented, under polarized light, "quite a large number of crystals of exceedingly beautiful appearance, perfectly round, and having a very smooth border. I may here remark that Mr. Chester feeds large quantities of corn to his thoroughbred Shorthorns, which possibly may have some influence upon the crystalline formation of the butter."

Figs. 1 to 7, Plate 2, represent the aggregate crystallizing forms of Holstein butters. It will be observed that only one of these illustrations, No. 6, exhibits secondary crystals. The butter of the Holstein milch cow seldom exhibits secondary crystals.

Figs. 1 to 12, Plate 3, represent groups of butter crystals of Jersey milch cows. The most remarkable bodies in the group, Figs. 8 and 9, represent rather the form peculiar to crystals of beef fat than to butter. They represent mostly crystals of the secondary type, and seem from evidence from two sources to be modifications, the result of a feed consisting partly of boiled cotton seed. Prof. Edward Mayes, Oxford, Miss., the owner of the Jersey cow that furnished the butter, writes that the feed consisted of "corn meal, timothy, and cotton seed." A letter from J. Stanley Pope, Tougaloo, Miss., gives the following in relation to feeding raw cotton seed:

> Yours of the 14th duly received. The butter is from a milking of six Ayrshire cows, all registered. It has been very dry here, so that pasturage is short, and the cows were eating a weed that grows rankly here, and it made the milk exceedingly bitter. I do not know whether it would modify the crystals or not.
>
> Their pasturage was Bermuda grass and Lespidoza. They were being fed one peck of raw cotton seed per day; no grain of any kind. Raw cotton seed makes a lardy butter. Of course feed has much to do with butter, and I do not regard raw cotton seed as good feed.

It is hoped that the effect of cotton seed on butter crystals may be further investigated at the experiment stations.

The crystalline form of butter must be necessarily modified by the quality and quantity of the feed, for the reason that the proportions of the fatty proximate principles of the plants on which cattle feed vary, some containing more oil than solid fat. The solid fats themselves vary very much in their proportions of stearin and palmitin. Plants generally contain a much larger proportion of palmitin and oil than is found in the fat of most animals.

OLEOMARGARINE AND BUTTERINE.

In all my experiments in the examination of butter substitutes, sold under whatever name, oleomargarine, butterine, etc., I have found but a trace of butter present in any sample.

On boiling decomposed oleomargarine, generally, a slight odor of casiene is perceived, showing the presence of butter, but no more

than would be occasioned by churning milk with a mixture of "oleo' and "neutral" lard. I have examined many samples of oleomargarine, received directly through agents from several of the largest factories in the United States, the object of the purchase being unknown to the proprietors, receiving a guaranty that the samples were of their best make, and have found that in each case they contained, as before stated, but a trace of butter. On crystallizing these samples by boiling and cooling them, the small crystals peculiar to "oleo" and lard, "neutral" lard, were found.

I have examined ten samples of butter-like substances, forwarded to the Microscopical Division by Hon. J. K. Brown, dairy commissioner for the State of New York. All of them proved to be fictitious butter. Several of the samples consisted of stearin, cotton-seed oil, and lard, colored to imitate butter.

Many samples bought for butter and afterwards suspected as oleomargarine proved on examination to be rancid butter, having a strong order of butyric acid.

USE OF TERMS.

Some scientific men, even chemists, frequently use the terms beef fat, "oleo," and stearin indiscriminately in discussions relating to the crystallography of fats.

Pure beef fat consists chiefly of the glycerides of stearic, palmitic, and oleic acids. Variations in the proportions of these fatty acids constitute the only essential difference between beef fat, "oleo," and lard. It is evident, therefore, that when changes are made in the proportions of these proximate principles of the fats, either by abstraction or addition, as in "oleo," it leads to confusion to apply the term beef fat to the new artificial compound.

OLEO.

"Oleo," a term applied by manufacturers of butter substitutes to a product expressed from beef fat, consists of olein and palmitin, with a very little stearin, the latter being a residue left in the press after the oil has been extracted by hydraulic pressure. The object of the manufacturer is to separate the stearin from the olein and palmitin, and thus obtain a product, "oleo," which approaches the composition of milk, butter. "Oleo," therefore, it will be understood, does not represent beef fat, much less does the separated stearin.

STEARIN.

Stearin is a glyceride of stearic acid. It does not crystallize as quickly as stearic acid, although much more rapidly than butter or lard. Were an ounce each of butter, lard, stearin, and stearic acid heated simultaneously in porcelain capsules and allowed to cool in a still atmosphere at a temperature of about 70° F., the stearic acid would chill and crystallize first, then the stearin, then the butter, and lastly the lard. Were an ounce of stearin and an ounce of butter melted together and cooled at the same temperature as above the compound would harden in thirty minutes to the consistency of tallow. An ounce of lard and an ounce of butter thus treated would not harden in less than from eight to ten hours.

STEARIC ACID.

The crystals of stearic acid differ materially from those of stearin. Pure stearic acid crystallizes quickly at ordinary temperatures. If a portion as small as a grain of mustard seed is placed on a slip of glass and gently heated over a spirit-lamp, a thin disc of glass being placed over and in contact with the acid while hot and then viewed by polarized light, crystals may be observed shooting out in all directions in characteristic forms.

COMMERCIAL STEARIN.

In the extraction of oleo oil from beef fat, or other varieties of fat, by means of hydraulic pressure, as in the manufacture of oleomargarine, a bi-product, known as stearin, is obtained. It is said that no manufacturer of good repute ever uses this crude fat in the production of butter substitutes, because of its indigestible character and for other reasons. In the course of my experiments I have found it necessary to examine and test samples of crude stearin. Through the courtesy of C. M. Vorce, esq., counselor-at-law, Cleveland, Ohio, I obtained recently three samples of this product, beef-fat stearin, bone stearin, and lard stearin.

The difference in their hardness on being boiled and cooled is quite marked. Beef-fat stearin, subjected to a temperature of about 300° F. for a period of several minutes and then slowly cooled in an atmosphere of about 60° F., becomes quite hard to the touch. Bone stearin treated in like manner is less firm, while lard stearin under the same treatment is softer than either of the preceding. The crystals in each case are branched and resemble those of beef fat.

Extract of a letter from Mr. Vorce, member of the American Society of Microscopists, a gentleman who has taken a great interest in the crystallography of fats:

* * * I have secured for your experiments three samples of stearin, marked as follows: "A. Pure lard stearin, clean and nice, fresh pressed." "B. Pure beef stearin, clean and fresh pressed." "C. Pure bone stearin, clean, recently pressed." The lard stearin I took from the hands of the stripper as he took it from the press-cloths. The bone stearin was pressed the day before. The beef stearin was standing in the press when I was at the factory, and was sent over from that batch later in the day. Bone stearin is made from the grease rendered from butchers' bones, and is composed of the marrow and hard fat together, the latter probably predominating. The grease is grained and pressed precisely as tallow is.

I visited all the lard-oil factories here without finding any lard stearin, as the oleomargarine law has killed off the lard-oil industry, except in Chicago and Kansas City. The slaughterers alone can afford to press lard. Then I tried the soap factories, also large consumers of stearin. None had any on hand, and are using instead the grained or crude tallow. Next I tried candle factories. None had any stearin except the "refined," which had not been bleached with acids, etc. Then I went for the renderers and secured the samples of lard, bone, and beef stearin I send you. I found out in the course of conversation with them at the Factory Rendering Works that the term "grease" covers all rendered material, tallow, lard, or bone grease. They call the stuff before rendering tallow or lard; after rendering they call it grease; after pressing it is stearin. "Fat" they apply to mixed, raw fat, butchers' clippings, etc. The slaughterers have quite a different use for the same terms. * * *

CONDITION OF FATS IN HEALTH AND DISEASE.

Incidentally to my microscopical examinations of butters and other edible fats, the fats and oils of many animals, wild and domestic, have been examined with a view to utilizing such as might be found

useful owing to special properties, or the discovery of any new property characteristic of any fat or oil that would assist by contrast in the detection of artificially mixed fats or oils, whether used as food, medicine, delicate lubricants, drying oils, or for other purposes.

The solid fats of animals accustomed to great muscular exertion, such as the horse, winged animals, and some fishes, seem to contain, as far as my observations extend, a larger proportion of oil than is found in the solid fats of animals of more sedentary habits.

The fats of consumptives, whether of man or the lower animals, victims of exhausting fevers, exhibit like conditions. Thus in the production of abnormal heat in the animal economy, whether arising from chemical or muscular energy, the result seems to be the same. The solid fats seem to be more readily consumed than the oil.

LARD EXAMINATION.

Agreeably to your request I have made a special examination of about 100 samples of lards, pure and adulterated, not only with the microscope, but by means of the color-reactions' test with sulphuric acid.

The result of my examination shows that nearly all of the samples were compounds of lard, cotton-seed oil, and beef-fat stearin.

The following apparatus and re-agents were employed:

Plate 4, Fig. 1, spatula (one-quarter size). Fig. 2, inverted saucer (full size). Fig. 3, porcelain mortar and pestle of any convenient size. Fig. 4, sulphuric acid, C. P., specific gravity 1.705. Fig. 5, graduated tube. Fig. 6, a test tube.

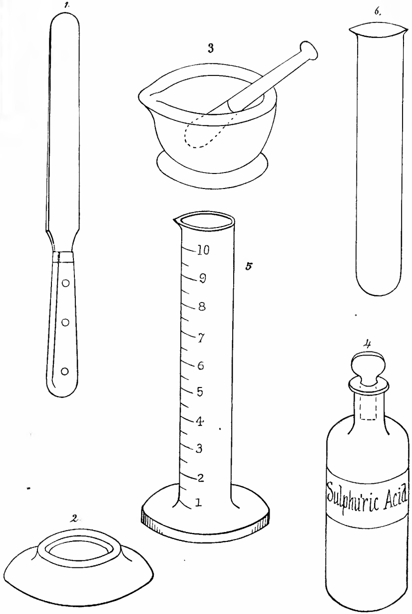
The lard oil is measured in Fig. 2, and in case of the former, smoothed evenly to the rim by means of the spatula. Transfer the fat or oil thus measured to the mortar, fill the graduated measure one-quarter full of sulphuric acid, and pour it on the fat in the mortar. Triturate the fat and acid for one minute and add a sufficient quantity of acid to fill the test tube into which the contents of the mortar are emptied two-thirds full and let it settle. In the case of mixed fats the sulphuric acid sometimes appears of a yellow or red shade in the lower part of the tube.

FLUORESCENCE.

It has been held heretofore that the fixed fats and oils are not fluorescent. (See Alfred H. Allen's Commercial Organic Analysis, vol. 2, p. 1, 1886.)

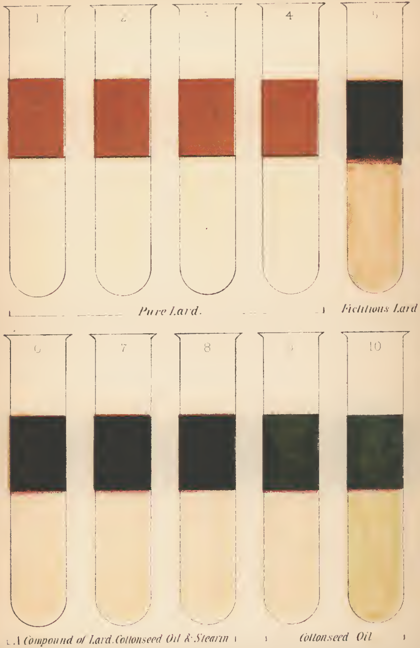
It may be well to explain for the general reader that by the term "fixed" fats and oils is meant those which make a greasy stain on paper, not removable by heat without destroying the paper. Essential oils are not oleaginous to the touch and make no permanent grease spot. In chemical constitution they present no relationship to the fats and oils. The stain of the essential oils may be readily removed at a temperature of 212° F.

Fluorescence is a term used by Professor Stokes in explanation of the phenomena called by Sir J. Herschel epipolic dispersion, and by Sir D. Brewster internal dispersion. Professor Stokes found that on examining the light produced by the solar spectrum falling upon a fluorescent substance it possessed a less refrangibility than the incident rays, and he was therefore led to the discovery of the change of the refrangibility of the rays of light, the highly refrangible actinic rays being degraded into luminous rays of less refrangibility.



J. Reynolds del.

Color Reactions of Pure Lard, Fictitious Lard & Cottonseed Oil, with Sulphuric Acid.



TAYLOR DEL. THE HATCH LITHO.

The above is a scientific statement of this phenomenon, but it can not convey to the general reader a definite idea of what is meant by fluorescence as applied to the fixed fats and oils. The following will, I trust, explain this remarkable behavior of some special fixed fats and oils under certain conditions of treatment:

If 100 grains of pure lard is triturated with about 400 grains of pure sulphuric acid freshly prepared of a given specific gravity, 1.705, and poured immediately into a test tube, two-thirds of the free sulphuric acid falls to the bottom of the tube colorless, while the lard, changes quickly to a cinnamon color, and floats on top. Any of the fixed fats or oils in the list given below, treated in like manner, will color the acid in the lower two-thirds of the tube a yellow or port-wine color, as the case may be, perceived on holding the test-tube toward the light. If viewed after the lapse of twenty-four hours by reflected light and slightly in the shade the phenomenon of fluorescence is apparent in a greenish tinge of varying depths of color.

FIXED FATS AND OILS, FLUORESCENT.

I have tested the following fixed fats and oils, and find that they have the property of fluorescence in a marked degree:

Palm.	Polar Bear.	Whale.
Chaulmugra.	Panther.	Loon.
Oleic acid, C. P.	Otter.	Alligator.
Tallow Tree of China.	Raccoon.	Pelican.
Turkey Buzzard.	Skunk.	Opossum.
Black-snake.	Dog.	Mullet.
Horse.	Domestic Turkey.	

I have also tested all the fats and oils employed in the manufacture of butter substitutes and find that none of them are fluorescent. Therefore, were any of the fluorescent fats or oils mixed with butter substitutes they would be detected by reason of this property.

I have made a compound of lard and horse fat containing only 4 per cent. of the latter, and detected the horse fat in the compound by its green fluorescence.

To obtain these results successfully it is absolutely necessary to adhere strictly to a certain specific gravity of C. P., sulphuric acid, as laid down in my method.

FATTY ACIDS, FIXED FATS, AND OILS NOT FLUORESCENT.

Stearic acid, C. P.	Beef fat, fresh.	Castor oil.
Stearine, C. P.	Lard.	Thibet Bear.
Palmitic acid, C. P.	Cotton-seed oil.	Cat (wild and domestic).
Palmitin, C. P.	Olive oil.	Beef dripping.
Commercial stearine.	Benne oil.	

The fats and fatty acids in the above list marked C. P. are as nearly pure as can be made.

DESCRIPTION OF THE PLATES.

PLATE 1. Butter crystals of the Jersey milch cow.
PLATE 2. Butter crystals of the Shorthorn milch cow.
PLATE 3. Butter crystals of the Holstein milch cow.
PLATE 4. Implements used in the sulphuric acid color test.
PLATE 7. Showing the color reactions with sulphuric acid of pure lard, cotton seed oil, and compounds of lard, cotton-seed oil and stearin (fictitious lard).
PLATES 5, 6, 8, and 10 have been withheld from publication to prevent delay in the issue of the annual report. They will be used to illustrate a forthcoming bulletin on butter and fats.

From whom samples of butter, fats, and oils have been received.

From whom received.	Sample.
U. S. Department of Agriculture, Division of Ornithology and Mammalogy.	Wild turkey fat.
	Hen hawk.
	Ruddy duck.
	Ring-necked duck.
	Hooded merganser.
	Barred owl.
	Screech owl.
	Badger.
U. S. Department of Agriculture, Bureau of Animal Industry.	Rabbit, 3 samples.
	Domestic fowl.
Smithsonian Institution	Elephant.
	Lion.
	Monkey.
	Badger.
	Great northern diver.
	Turkey buzzard.
The National Museum	White swan.
	White pelican.
	Seal.
	Tallow tree of China.
American Museum of Natural History, New York	China goose.
	Armadillo.
The Zoological Gardens, Philadelphia, Pa	Polar bear.
City dog-pound, Washington, D. C	34 samples dog fat.
Fat-boiling establishment, Anacostia, D. C	5 samples horse fat.
Fat-boiling establishment, Alexandria, Va	Animal fats, mixed.
United States Treasury, Bureau of Internal Revenue	33 samples of oleomargarine.
Seventh street office, Bureau of Internal Revenue	3 samples of suspected butter.
City police court	12 samples of oleomargarine sold for butter.
National Medical College	Suspected butter.
Factory, Baltimore, Md	Samples of oleomargarine.
Armour & Co., Chicago, Ill	3 samples of oleomargarine.
	Neutral lard, lard, and oleo.
Harmony Creamery, McHenry County, Ill	Butter.
Factory at Waterloo, Iowa	Do.
East Liberty Creamery, Ohio	Do.
Lewiston Creamery Company, Missouri	Do.
Pool, Gardiner & Co., Massachusetts	An unknown fat found in the Atlantic Ocean.
Massachusetts Agricultural College	Samples of butter.
Missouri Agricultural College	Do.
Connecticut Agricultural College	Do.
Creamery, Franklin Bros., Tennessee	Do.
Sandmon & Co., New York	Butterine.
Proctor & Gamble, Cincinnati, Ohio	Cotton-seed oil stearin.
Various wholesale dealers and dairies in the city of Washington.	Butter, oleomargarine, etc.
From all parts of the United States, branded with the merchants' stamp.	Lard, stearin, cotton-seed and other oils to the amount of over one hundred.
Alvord, Major H. E., Massachusetts Agricultural College	Shorthorn Jersey, Guernsey, Holstein, Ayrshire.
Brown, Hon. J. K., State dairy commissioner, New York	Oleomargarine, 10 samples.
Ballinger, J., Virginia	Butter.
Burmite, W. H., Delaware	Do.
Crane, New York City	Mixed fats.
Deitrich, Virginia	Butter.
Darlington, Delaware County, Pa	Do.
Elder, B. Winchester, New Orleans, La	Cotton-seed oil stearine.
Franklin, N. H., Tennessee	Pure unsalted butter.
Gray, J. Bowie, Fredericksburgh, Va	Shorthorn butter.
Guittar, Gen. O., Missouri	Butter.
Gold, Hon. T. S., Connecticut	Do.
Hatch, Hon. W. H., Hannibal, Mo	Jersey butter.
Harwood, P. M., Barre, Mass	Holstein-Friesian butter.
Harvey, John, Washington, D. C	Jersey and Shorthorn butter.
Hart, Mrs. Maria, Washington, D. C	Butter from New Jersey and Virginia.
Kilbowe, F. D., Washington, D. C	Bear fat and skunk's oil.
Lewis, Mrs., Virginia	Raccoon fat.
Lukens, C. C., Fairfax County, Va	Jersey butter.
Latham, Mrs. F. E. B., Florida	Alligator, rattlesnake, bear, black-snake, panther, otter, mullet, pelican, opossum.
Mitchell, Joseph, New Jersey	Butter.
Mayes, Hon. Edward, Oxford, Miss	Jersey butter.
Morgan, Dr. Carroll, Washington, D. C	Horse fat.
Miller, S. T., Constableville, Lewis County, N. Y	Deer fat.
Member of Congress	Butter and oleomargarine.
Nichols, Frank, West Virginia	Butter.
Olcott, J. B., superintendent experiment station, Connecticut.	Do.
Pease, F. S., Buffalo, N. Y	Palm fat, stearic acid.
Pope, Rev. J. Stanley, Tougaloo, Miss	Ayrshire butter.
Phillips, Mr., Washington, D. C	Butter.

From whom samples of butter, fats, and oils have been received—Continued.

From whom received.	Sample.
Quick, Vanderbilt, Virginia	Alderney butter.
Queen, James W., & Co., Philadelphia, Pa	Stearine, palmitin, stearic, palmitic, and oleic acid.
Rowe, M. B., Fredericksburgh, Va	Jersey butter.
Radcliffe, Dr., Washington, D. C	Butter.
Shepherd, Mrs., Washington, D. C	Do.
Stowell, Prof. C. H., Ann Arbor, Mich	Do.
Sharpless, P. H., Delaware County, Pa	Do.
Skipwith, P. H., Mississippi	Holstein butter.
Story, Mr., Washington, D. C	Butter.
Sanborn, Prof., Missouri Agricultural College, Missouri	Shorthorn, Jersey, and Holstein butter.
Vorce, C. M., Cleveland, Ohio	"Oleo," bone stearin, beef stearin, and lard stearin.
Wilson, Hon. James F., Iowa	Jersey butter.
Ware, Hon. B. P., Massachusetts	Ayrshire butter.
Farmer in Prince George's County, Md	Three samples of butter from cows of no especial breed.

Respectfully submitted,

THOMAS TAYLOR,
Microscopist.

Hon. NORMAN J. COLMAN,
Commissioner.

REPORT OF THE POMOLOGIST.

SIR: I have the honor of submitting to you my second annual report as chief of the Division of Pomology, and hope it may be received by yourself and by the public with due allowance for the limited funds and clerical assistance at my command.

It is my aim to serve the cause of practical and scientific pomology in such a way as to accomplish at least a part of the good you and many others had in mind when the division was established.

The year 1887 may really be said to be the first in which I have had opportunity to get the machinery of this division into good working order.

On the 1st day of February of this year Mr. Charles L. Hopkins, of Florida, was appointed as clerk to assist me, and on August 1 Mr. William H. Prestele, of Iowa, was appointed as artist of this division.

The very small appropriation of $3,000 for the fiscal year beginning July 1, 1887 (the same amount as for the previous year), did not permit me to undertake any very large work, especially as the salaries of these two persons and all other expenses of the division had to be paid out of it. The steadily increasing correspondence of the office has been a heavy burden.

Up to August 1, when Mr. Prestele took his place here, there was no one to make drawings of the fruits which were being daily received for study and comparison, except myself, and I had neither sufficient time nor proper skill to devote to it. Prior to that time I was only able to make pencil drawings of the more important varieties received, and a careful record and minute description of them; but since then a part of the drawings have been made in India ink, and others have been reproduced in water-colors, all in the most skillful manner, showing the natural size, shape, and color of both exterior and interior of the fruit, with the leaves and twigs characteristic of each. These are invaluable for comparison and reference, and a portion for publication.

A photographic apparatus has been purchased, which will be used to take views of such trees, orchards, vineyards, or other subjects as it may be necessary to preserve, or present in published form in the reports.

A compound microscope of high power, together with necessary appliances to be used in connection therewith, have been secured for the use of the division. Also a very good microtome has been purchased with which to make sections for microscopical study. It is my desire to make use of every possible means to investigate and study the complex questions of a pomological character, or such as are directly connected therewith, as they may arise. For instance, the pollen of different botanical species and of the varieties of each species should be examined, and their physiological characters and

differences well understood. This is very important in the study of the scientific principles which underlie practical pomology.

In accordance with your directions, there have been prepared for publication within the present year the following manuscripts: By Mr. P. W. Reasoner, of Manatee, Fla., a report on "The Condition of Tropical and Semi-Tropical Fruits in Florida and the Gulf States;" by Mr. W. G. Klee, of Berkeley, Cal., a report on "The Condition of Tropical and Semi-Tropical Fruits in California, Arizona, and New Mexico." These two reports, together with a few notes by myself upon the same general subject, and colored illustrations of Japanese plums and persimmons, constitute Bulletin No. 1, of the Division of Pomology. It has been in the hands of the Public Printer since December 1. Also, by Mr. T. T. Lyon, of South Haven, Mich., a report on "The Adaptation of Russian and Other Fruits to the Extreme North and Northwest Portions of the United States." This report is also in the hands of the Public Printer and will be issued as Bulletin No. 2. It was my desire to have both of the above-named bulletins issued promptly, and it is to be regretted that the want of sufficient appropriations should have delayed their publication.

An article was prepared by W. H. Ragan, of Greencastle, Ind., entitled "Our Fruits, Native and Introduced," which gives information of a character that should be issued by this Department, and it is now awaiting publication.

A monograph has been prepared by T. V. Munson, of Denison, Tex., entitled "The Native Grapes of the United States." This is a scientific treatise of an unusually valuable and interesting character, and should be published with illustrations in colors, showing a portion of the branch, leaves, fruit, flowers, and seeds of each of the twenty-one species native to this country. A part of the original illustrations to accompany the text have already been prepared, and it is my purpose that the artist, Mr. Prestele, shall prepare, during the next fruiting season, an accurate, typical, and life-size water-color painting of each species, with a view to the whole being published in the highest style of art. Certainly this subject is one that deserves to be placed before our people in the most lucid manner possible. It is my earnest desire that within the next year this matter shall receive the favorable and necessary action of Congress to enable this work to be done.

THE APPLE.

The condition of this, the most important of all our fruits, during the year 1887, was somewhat peculiar. In the States of Ohio, Indiana, Illinois, and parts of several adjoining States, where apples are usually very abundant, the crop was almost a total failure. In Connecticut it was very heavy, and in western New York, and most of the New England States and parts of Michigan, there was a plentiful supply. The northwestern part of the southern peninsula of Michigan, which is commonly called the "Grand Traverse Region," produced a large crop for the amount of orchards planted. The climate there seems peculiarly well adapted to the growing of apples, and especially late keepers. The samples grown there were the very last to disappear in this office, which was about the 1st of June. Missouri, Kansas, northern Arkansas, Kentucky, Tennessee, and western North Carolina had about half a crop in some localities, the fruit, in size and quality, not being up to the standard, because of the unusual drought which prevailed.

Very good keeping apples were sent me from Tennessee and Mississippi, and summer apples of very fair quality were received from Louisiana.

In the region embraced by Minnesota, Wisconsin, Iowa, Dakota, and northern Nebraska the successful culture of the apple has been almost despaired of by some, owing to the ruinous effects of the remarkably severe winters of the past few years. Others are as hopeful as ever, and are replanting their orchards in firm belief that they will gather abundant crops from them.

Some depend on Russian varieties imported by this Department in 1870 and those brought over at later dates by other parties; notably among these Prof. J. L. Budd, of Iowa Agricultural College. Others place but little dependence on these Russian varieties because of the poor quality, the early ripening of their fruit, and their peculiar susceptibility to the attacks of blight. Many of those most sanguine of success are looking to a race of new seedlings, which shall be the result of crosses between the best apples known and either the hardiest Russian varieties or crabs. It is thought the good qualities of the fruit of the former and the hardy constitution of tree in the latter may be blended in the coming generation. Tedious and painstaking efforts are being made in this direction, especially in Iowa, Wisconsin, and Minnesota.

Feeling the importance of the subject, and with a view of learning just what is the real condition of the fruits of this territory, Mr. T. T. Lyon, of South Haven, Mich., who is a pomologist of eminence and entirely disinterested motives, was commissioned, under the supervision of this division, to carefully examine and report thereon.

On the Pacific slope the apple crop was fairly good. Oregon and Washington Territory produce apples of remarkably large size and of better keeping qualities than those grown in California. The latter State, however, grows a greater supply of apples than most persons suppose. Nevada, Idaho, Utah, and New Mexico also grow apples to some extent. Colorado has many orchards beginning to bear.

DISEASES.

A great many inquiries come to me for remedies for Bitter Rot and Scab, but as these are matters which pertain to the special work of the Mycologist of this Department I have referred them to him for answer. It might, however, be proper to say, that so far, no remedies have been found for either of the above maladies.

INSECT DEPREDATIONS.

I have had frequent questions and reports sent to me on this subject, but they properly belong to the Entomological Division, and have been there referred. It is with extreme satisfaction that I am informed of the increasing success of spraying the trees with arsenical poisons to combat the Codling Moth.

VARIETIES.

I desire to mention a few new varieties which have come under my notice, and some old ones of special value but little known. It is really unaccountable how varieties of fruits of most excellent character are overlooked or neglected by the general public. Notably among these is the apple known as

Summer Rose.

In my opinion this little favorite surpasses Carolina June, Early Harvest, and all the other early apples I know. It is as early as any, begins to bear soon after planting, and seldom fails to bear a good crop, even when most varieties fail.

The tree has a beautiful round head, the branches are stout but not heavy, with very distinct gray dots upon the new growth. It is essentially a family apple, beginning to ripen with the very earliest and continuing for about six weeks. It sells well in market, but is more especially a dessert variety. Originated in New Jersey.

Size, small, 2 to 3 inches; shape, flat to round, regular; surface, very smooth; color, white, with stripes and splashes of the most delicate tints of carmine; dots, very small; basin, wide, abrupt, and rather deep, regular; eye, small and colored; cavity, narrow, regular, not russeted; stem, usually quite short; core, large, closed, regular, meeting the eye; seeds, numerous, short, and plump, light brown; flesh, white, with rarely a tint of pink next the skin, fine grained, tender, crisp, juicy except when overripe; flavor, subacid, very pleasant; quality, as good as the best of the early kinds; season, from June to August, in the central States.

The illustration on Plate 4 is from a specimen grown on my own farm at Geneva, Kans.

Ozark.

This variety originated with Mr. Thomas Morchal, jr., of Crowell, Benton County, Ark. In the spring of 1884 he dug up a sprout from the stump where a Ben Davis tree had been broken down, and planted it. In the fall of 1887 this tree bore over a bushel of apples, and the specimen from which the drawing and description were made was sent me by G. F. Kennan, of Brightwater, in that county, but was grown on the original tree.

Size, large, 3 to 4 inches; shape round, regular, but sometimes unequal; surface, very smooth, light yellow, covered with suffused bright carmine; dots, small, light, on raised basis; basin, deep, wide, abrupt, regular; eye, small, closed or nearly so; cavity, wide and deep, russeted but little; stem, short, slender; core, regular, closed; seeds, large, long, dark; flesh, white, tender; flavor, subacid; quality, good; season, November to December, in northwestern Arkansas.

Bella.

This is a new variety brought to my notice by Charles P. Augur, of Woodbridge, Conn. The original tree stands near that place on a slaty hillside in a pasture belonging to Timothy Fowles. It is what might be called an open grower, and carries its fruit mainly on the outside branches. It bears annually and abundantly. Mr. Augur has sent cions to various States, and hopes to get favorable reports from them in due time.

Size, medium to large, 2½ by 3 inches; shape, round or nearly so, slightly conical, irregular but not ribbed or angular, unequal; surface, smooth, greenish-yellow thinly and partially covered with dull mixed red and darker splashes and blotches; dots, scattering, medium size, gray, prominent; basin, quite shallow, slightly folded; eye, open, shallow; sepals, short; cavity, shallow, narrow, heavily and

widely russeted; stem, short; core, small, nearly closed, clasping the eye; seeds, numerous, plump, light brown; flesh, yellow, a little coarse, but tender; flavor, mild subacid, pleasant; quality, good; season, in Connecticut, November to January.

Star.

Although this is an old variety of uncertain origin, but probably Orange County, N. Y., it is thought highly of by many growers. It is not a very showy apple, but well worth a place in a family orchard. The drawing was made from specimens grown by L. B. Pierce, of Talmage, Ohio.

Size, medium, 3 to $3\frac{1}{2}$ inches; shape, flat, slightly conical, unequal, regular; surface, smooth, greenish-yellow, with occasional slight show of red; dots, numerous, dark, prominent; basin, shallow, regular; eye, small, closed; cavity, rather shallow, sloping, regular, russeted; stem, short, slender; core, wide, almost closed, clasping; seeds, small, plump; flesh, whitish, tender, juicy; flavor, mild subacid, rich, pleasant; quality, very good; season, September to December, in Ohio; use, kitchen and dessert.

Huntsman.

Although this apple has been described many years ago by Charles Downing and others, it is of so much worth and comparatively little known to the general public that I venture the repetition. Having originated in Missouri it has become best known in the West. It has, however, been grown in many parts of the country, and is generally highly praised. The tree is quite satisfactory in every way, and there is no yellow winter apple which sells better when sent to market. My specimens are from Abner Allen, of Wabaunsee, Kans.

Size, large, 3 inches, and often reaching 4; shape, flat, nearly always unequal, waved near basin; surface, smooth; color, a rich yellow, with very rarely a faint blush; dots, large, distinct, dark; basin, wide, rather deep, waved; eye, generally open, deep; cavity, wide, sloping, not russeted; stem, medium to short; core, large, wide, open, clasping the eye; seeds, large, plump, dark; flesh, yellow, fine grained, firm, juicy; flavor, subacid, rich, aromatic; quality, excellent; season, December to spring, in Kansas and Missouri; use, dessert and market.

Harbour.

This variety came to me from Mr. B. F. White, of Mebane, Alamance County, N. C. It originated in that county many years ago, and is thought to be a seedling of Abrahm, which it resembles in both tree and fruit in many respects. It is, however, a much better apple in nearly every way.

Mr. Harrison Harbour, of that locality, rescued it from extinction by getting a few buds from the old tree, which was about dead, and setting them in his own orchard. In a few years they bore fruit, and he called the attention of a nurseryman to the variety, who named it in Mr. Harbour's honor. The tree is rather slow in growth but very hardy and long-lived. The fruit is evenly distributed over the tree, and hangs on with tenacity until cold weather. A little freeze does not hurt it. It is pre-eminently a winter apple. Its bright

color and rich aroma enhance its value greatly. The illustration (Plate 9, Fig. 1) was made from a specimen sent by the gentleman above named.

Size, small, 2 to $2\frac{3}{4}$ inches; shape, flat or apparently round, regular; surface, smooth, the yellow under color nearly covered with bright carmine, diffused striped and splashed, a light bloom where not handled; dots, small, indistinct, yellowish gray; basin, abrupt, deep, almost regular; eye, small, open, shallow, segments of calyx reflexed; cavity, medium to shallow, regular; stem, short, slender, straight; core, small, broad, open; seeds, large, broad, dark; flesh, yellow, crisp, firm, juicy; flavor, subacid, rich, very pleasant; quality, very good; season, January to late spring in North Carolina.

Orange Winter.

This variety originated with Mr. Orange Winter, of Sauk County, Wis., from seed of Perry Russet which it resembles in tree, except that it is more hardy and productive. The buds and leaves are very thickly set along the twigs. It was introduced by J. W. Shoards, of Reedsborough, Wis., and given the above name in honor of the originator. I have endeavored to have the name changed to something less common and that would not be misleading as to its season, but this seems to be quite impossible from the fact that it is already widely distributed under that name. My specimens were from Mr. A. L. Hatch, of Ithaca, Wis.

Size, large, 3 to 4 inches diameter; shape, flat, a little inclined to one side; surface, a little rough, dull yellow, not blushed; dots, numerous, very small, prominent; basin, wide, deep, waved but not folded; eye, deep, closed; cavity, wide, sloping, not russeted: stem, medium in length and thickness; core, very broad, but closed; seeds, pointed, plump, dark; flesh, yellow, rather coarse; flavor, subacid; quality, good, but not extra; season, October and November in Wisconsin.

THE GRAPE.

The grape crop of 1887 was very good, except in a few localities where the Black Rot affected it; but as this disease is induced in a great measure by frequent rains and a humid atmosphere, and as the reverse of this was true in the greater portion of the grape-growing area of the United States, little damage was sustained. Grapes were plenty and cheap in the markets. In California the grape succeeds admirably. The varieties grown there are entirely different from those of the Eastern States and belong to the species *Vitis vinifera*. There are thousands of acres in a single vineyard. The Napa valley is almost entirely devoted to the growth of the vine. I have been credibly informed that as much as 17 tons of grapes have been grown on an acre in several cases, and that 10 tons per acre is by no means rare. From what I saw there I have no doubt of the truth of these statements.

Grapes are there chiefly made into wine, but the manufacture of raisins is becoming a leading industry. This is especially true of that portion of the San Joaquin valley in the vicinity of Fresno and Tulare. I know that for the production of raisins this region is peculiarly adapted. The soil is excellent, the water supply for irrigation abundant and cheap, and the long rainless season during ripening peculiarly suitable.

The Sacramento, Sonoma, Santa Clara, and Santa Ana valleys also produce good raisins, and in the vicinity of San Diego they are made equal to any that I have ever tasted from Europe. The raisins of the El Cajon are famous, and will be more so as time goes on. In fact, the importation of foreign raisins is already checked, and we are likely to be able within the next ten years to produce within our own borders all the raisins our people will need.

Arizona is also coming to the front in this matter. The Salt River, Gila, and other valleys can grow good grapes of this class, and the long, hot, and dry summers and falls are well suited to curing them into the best of raisins.

New Mexico and the extreme western portions of Texas, notably about El Paso, can also grow the foreign grapes. The cold of the winters, however, makes it necessary to cover all the vines with earth during the time of danger. When so prepared the vineyards resemble fields of huge sweet-potato hills.

Florida has not been generally thought suited to the growth of the grape until within the last few years. Experiments are now being made with many varieties, both foreign and native.

Many new varieties are being each year brought to notice all over the country, and a very few are noticed in this report.

Eaton.

Among those for which much is claimed is the Eaton. It originated with Mr. Calvin Eaton, of Concord, N. H., about 1868. The vine is a very strong grower, with large leaves of the Concord type, It is said to be as hardy as that variety. The cluster is of moderate size, but the berries are extra large for a native American grape. The color is black, and the season medium. Skin rather thick. In flavor I do not think it quite equal to the Concord, although others think it fully equal. It deserves trial.

Lutie.

This grape originated in Tennessee and is there thought of superior quality, especially as an early variety. Not having been able to get samples of it, I defer a more extended notice of it until I can obtain them and speak from more intimate acquaintance.

Jewell

Was referred to in my report of last year, and another year's experience with it in the hands of the few who have fruiting vines seems to indicate that it is a valuable variety. I would at least recommend that it be given a fair trial.

Ten new seedling grapes were sent to this division in proper season from Mr. Theophile Huber, of Illinois City, Ill. They were nearly all of good quality and deserve to be better known. The two following are of that number:

Emma.

This is, to my mind, the best in quality of the whole lot. The cluster is of medium size, well shouldered, and rather open. The berry is medium size and round. The skin is very thin and tender

and of a beautiful translucent yellow color. In flavor it is rich and delicate and without foxiness. The pulp is very tender.

Marie Louise.

This is another of Mr. Huber's seedlings. The cluster is about like that of Concord. The berry is round, rather thick skinned, and in color a rich greenish yellow. The flavor is very pleasant.

THE PEACH.

Taking the country over, the crop of 1887 was a failure. In a very few sections it was medium, but nowhere heavy. Severe cold in winter, spring frosts, "yellows," and the ravages of the "rose-bug" (*Macrodactylus subspinosus*), although acting in different localities, have combined to produce this unfortunate result. California alone had a good crop. What few peach trees there were in Arizona large enough to bear, produced abundantly. Specimens were received from there on November 20 in such sound condition that they were kept for fully a month later. These specimens came under the name "December Cling" and were of a whitish color and rather poor quality, but it showed what has been done in that region, and suggests what else might be done. In Florida, southern Texas, and other sections lying next the Gulf of Mexico, a different class of peaches must be grown from those that succeed in the North. But as this subject is specially treated in a report by Mr. G. Onderdonk, of Nursery, Tex., which appears as part of the present report of this division, I will only say that there is no doubt of the truth of the above statement. The Asiatic varieties seem to do best, and I hope next year to give a detailed account of some of the newer varieties belonging to this strain. Mr. J. A. Bidwell, of Orlando, and Mr. James P. De Pass, of Archer, Fla., have brought out several new varieties of this character which are worthy of extended trial in that State. Mr. Onderdonk, of Texas, has long been engaged in similar experiments.

THE PLUM.

There is an increasing interest in plum culture in many parts of the country. Of course California and Oregon are far ahead of all other States, because of the absence of curculio. All species of plums do well there, but the European varieties are almost entirely planted. The bulk of the crop is dried, and is already having a marked effect upon our importations. The quality is fully equal to the best foreign brands. I have never seen elsewhere such large and fair-looking dried prunes as those sent to this office from Oregon. They were made from Coe's Golden Drop plum. Arizona, New Mexico, and the Rio Grande valley, near El Paso, Tex., also grow good plums of similar varieties because of their exemption from curculio.

In all that part of the United States lying east of the continental divide this insect pest still holds sway, with the exception of a very few localities. The most favored of these is a strip including but a few counties lying next to Lake Michigan between Grand Haven and the Straits of Mackinac. Thousands of bushels of the best of plums were shipped from there to Chicago, Milwaukee, and other

markets during the past year. In western New York and some parts of New England a few were grown. With native American species much better success is generally attained, because the larva of the curculio for some reason does not thrive so well as in the European species. Wild Goose, Miner, De Soto, Newman, Marianna, and Robinson are among the best of this class. Where several varieties are grown near each other they seem to bear better than where only one variety is planted, and it is thought this is the result of cross-pollenation However this may be, I would advise mixed planting, judging by the reports of many growers and by my own experience. In any case no harm can result, and the grower will have a succession of fruit.

Japanese plums are being more generally planted, and especially in the South. That there may be varieties from Japan which will prove to be hardy in the North is possible, but as yet I am by no means certain that any such which bear good fruit have been introduced.

The following varieties are mentioned, for reasons stated in the descriptions of each :

Kelsey.

This plum was described in my annual report of last year. Another year's experience has proven it to be gradually becoming more and more popular in the Southern States and California. It continues to bear well, but is not exempt from the attacks of curculio in regions where that insect abounds. Specimens from Prof. J. N. Whitner, of Lake City, Fla., were badly stung.

The colored plate of this variety which appears on another page (Fig. 1, Plate 1) was made from specimens sent by Prof. E. Hilgard, of Berkeley, Cal. The size, shape, and color of the fruit, as well as the leaves and bark, resemble the specimens as near as they could be made, and are in no sense overdrawn.

The flesh is quite firm, of a delicate yellow color, and clings to the stone. The flavor is equal to that of the ordinary varieties cultivated in the United States. In each specimen examined by me there has been a peculiar cavity of an irregular shape near the seed, similar to that shown in the illustration. It seems to be a characteristic of the variety.

The tree is of upright habit and thrifty in growth. The leaves are rather narrow and lanceolate, like those of Wild Goose and other native American plums.

Owing to the early blooming of the Kelsey the fruit crop is often cut off by frost, especially in the Gulf States. I desire to reiterate the statement of last year that the tree is about as tender as the fig, and will not endure the winters north of Texas, Tennessee, and South Carolina. Even there the trees are sometimes tender.

Owing to its very late ripening the fruit would not mature in the Northern States, even if the trees would grow there. There has been some difference of opinion as to its hardiness, and some have claimed that trees of Kelsey have withstood the winters of New York and New Jersey. In view of the fact that Kelsey trees have been positively known to have been killed by the winters of northern Texas, it is quite probable that those in New York and New Jersey so reported are spurious. If this should prove to be true, it is evidence that mistakes have been made in sending some other variety of Japanese plum to the above States under that name.

Satsuma.

This is a variety of plum which is native in Japan, and of very recent introduction here. The only tree in bearing in America, so far as I have been able to learn, is one on the premises of Luther Burbank, of Santa Rosa, Cal. The specimens from which the accompanying colored plate was made (Fig. 2 on Plate 1) grew there.

The tree looks much like Wild Goose plum, and may prove to be more hardy than Kelsey. This, however, is not yet known, but trees will next year be tested in many places both North and South. It bears very abundantly. The fruit is of a pleasant flavor and, unlike all plums, either native or foreign, before tested in America, it is red-fleshed.

The stone is remarkably small. The illustration is as true to nature in all respects as art could make it.

Blackman.

In addition to the statements made last year regarding this variety I have to say that it has continued to prove itself of no value, because of the trees being universally and entirely unfruitful. There being some question as to the real character of this variety, early in the spring of this year I wrote to several of the most reliable nurserymen and fruit-growers of the country for cions from bearing trees on their grounds, and requesting them to keep a close watch on the behavior of the variety. Mr. W. C. Barry, of Rochester, N. Y.; Hoopes Bros. & Thomas, of West Chester, Pa., and Mr. E. B. Engle, of Marietta, Pa., each sent me specimens. They were all in good condition and well supplied with fruit buds, and of the same variety which I have without exception seen in the nurseries and orchards of Texas and other States under this name.

Later in the season these parties wrote me that to their astonishment none of the fruit buds on their trees developed into blooms, but dropped off as if they had been killed by frost, when there was no frost to kill them. In other words, they seem to have been abortive from some natural defect.

I also addressed Mr. W. M. Clark, of Nashville, Tenn., who I had learned was acquainted with the early history of this so-called plum, asking him to report to this division what he knew of the matter, and to visit the original tree and send me cions from it. In response to this request he sent me the following, under date of March 24, 1887:

> My mother (Mrs. Charity Clark) visited, just after the war, Dr. James E. Manson, a nurseryman of Rutherford County, this State, and brought away some plum seeds from an orchard composed of Wild Goose and Washington plums, and gave them to Dr. Blackman, who planted them. This tree came up with others, and when it bore fruit it was seen that it was different and superior to them. I send a few twigs from two trees, both differing, one never having borne fruit (I mark it "mule"), the other the Blackman plum. And thereby hangs a tale: Mr. J. J. Newson, a nurseryman here, procured buds from the former tree and widely distributed the trees propagated from them. The Rose Bank Nurseries, owned by Truett's Sons, of Morgan, Tenn., sent an agent to Blackman's and got a large lot of slips or cions from the "mule," mistaking the tree, because it resembled the ordinary plum less than the genuine tree. Thus we have *two* Blackman plums, one genuine, the other spurious. Of course, those purchasing of the Rose Bank Nursery believe it to be a humbug, while those buying from Newson must be delighted with it.

Again, under date of April 13, 1887, he says:

According to your second request, I repaired at once to Dr. Blackman's, but found the flowers very scattering on the tree from the effects of age and frost. On the "mule" flowering had been intercepted entirely by frost, but I secured the embryo of this, and all the flowers I could of the other, and now have them under pressure and will send them as soon as dry.

It will be seen from these letters that there were two seedling trees on the premises of Dr. Blackman from which buds have been taken by two rival nursery firms and sent out to the world, one of which was probably good and the other worthless. By some ill-fortune the valuable variety has not been generally distributed, but the bad one has been sent far and wide. The samples from this original "mule" tree sent to me by Mr. Clark correspond exactly with all those received from nurserymen and seen by me in many States. It is rather a significant coincidence that the fruit-buds on this original tree failed to open into flowers, just as in the cases of those on the premises of Hoopes Brothers & Thomas, and others.

The other seedling tree in Dr. Blackman's yard (having since died) produced flowers, and the samples of branches and flowers of it sent here by Mr. Clark appeared almost identical with Wild Goose plum, but very unlike the variety under consideration. It has recently been named "Charity Clark" by Dr. Blackman and Mr. W. M. Clark, of Nashville, Tenn., who have the prior right to give the name the fruit shall bear, and in honor of Mrs. Clark, who got the seed of Dr. Manson.

That such a mistake should have been made (and no doubt it was a mistake on the part of Truett's Sons, of Morgan, Tenn., in getting buds from the wrong tree, and not an intended deception) is a serious matter to many nurserymen who have propagated the variety largely, and to many growers who have planted trees of it. Although thousands of dollars have been lost on this worthless freak of nature under the name of Blackman plum, the discovery by me of its true character when in Texas, in 1886, and having informed the public of the same at once through the public press, checked its distribution and saved the country from further waste of time and money.

Any persons yet having trees of this spurious variety should either dig them out or graft them. That there may be no uncertainty as to their identification, I will say that the tree in both leaf, bark, and arrangement of buds almost exactly resembles those of a peach tree. It is moreover a very thrifty grower. It is thought by several expert botanists to be an accidental cross between the peach and plum, but of course this is only the presumption entertained from the fact of the original tree having grown from the seed of a Wild Goose plum and from examination of its general characteristics. As a tree it is a success, but as a fruit a complete failure.

THE ORANGE.

(*Citrus auranteum.*)

The culture of this fruit in the United States is rapidly increasing. What is known as "the big freeze of 1886" in Florida, and which was indeed unparalleled in the history of that State, did not materially injure the orange trees there. In Louisiana a considerable area lying near the mouth of the Mississippi River is devoted to this fruit, and excellent oranges are grown there. In the immediate vi-

cinity of New Orleans the orange orchards were badly hurt by the freeze of 1886, and many of them have not yet recovered. In California, as far north as Redding, which is within sight of Mount Shasta, I saw orange trees in bearing. What is known as the "thermal belt" extends along the foot-hills of the mountain ranges, and it is in this belt that the orange grows in the central and more northern parts of the State. In the extreme southern counties the culture is carried more into the valleys, and especially at Riverside is this true.

Ripening at different times, as do the oranges of these States, our markets are or can be supplied with this delicious and healthful fruit for more than half the year.

In addition to this, new varieties are being originated and brought to notice, some of which are fully two months earlier than the earliest kinds before known, and some are fully that much later than the latest varieties in general cultivation. The main orange crop of Louisiana ripens from November 1 to February 1, that of Florida from December 1 to March 1, and that of California from February 1 to May 1. This covers six consecutive months, and a little more is gained both before and after this period by artificially handling the fruit.

It should always be borne in mind in considering the qualities of the oranges of the different sections of the country that climate has a marked effect upon this as well as all other fruits. The skin of nearly all varieties is thicker and more free from defects in California than in Florida and Louisiana and the flavor much more tart. The misunderstanding of this fact often leads to much confusion regarding the identity of varieties and their adaptability to certain localities.

Those that are very mild-flavored should not be grown in Florida, because they become insipidly sweet, and those of very tart flavor become really sour in California. If such kinds are planted reversely to the above they will in both cases be much improved.

In one, and only, one rare case I tasted a seedling orange grown in California that was so very mild-flavored as to be almost tasteless. In Florida and Louisiana the flavor of all oranges is usually very mild and pleasant.

The following varieties are worthy of special mention:

Satsuma.

From the best authority I have at command, this variety came from Japan to the United States about 1876. It has been grown in Florida since that time and is there known as the hardiest of all oranges. It is named after the province of Satsuma, in Japan, where it is largely grown.

At a later date it was brought to California. Recently thousands of trees of this variety have been imported from Japan by several firms in California under the name Unshiu (or as some have it, Oonshiu, to better indicate the pronunciation), which may be a common name for it in Japan. But as Satsuma has been applied to it in the United States for many years previous to these later importations it seems best to give the last name the preference. Having examined and eaten the fruit sent directly to this office from Japan, that imported and sold in California, and having also gathered specimens with my own hands from the trees in that State under the name Unshiu, and also having received it from many places in Florida

under the name Satsuma, I am fully convinced that all these samples were of the same variety.

The tree is described by my Japanese correspondents as spreading and dwarfish or even bushy in habit, very productive, and with broad leaves like ordinary oranges. This accords with what I have seen in California and what is reported to me from Florida. It is of the class to which the title "mandarin" is applied, because of its small size, flat shape, and very loose skin, which are characteristics of that class.

The illustration on Plate 5 of this report was made from specimens from Lyman Phelps, of Sanford, Fla.

Size, small to medium, 2 to 3 inches; shape, flat, a little pointed next the stem; color, bright orange; skin, rough, wrinkled next the stem, very loose and easily separated from the flesh; core, almost none, but instead a cavity often three-eighths inch in diameter in center; seeds, almost wanting; flesh, orange color, darker than the skin, not so juicy as some; flavor, very sweet, rich, very aromatic, peculiar; quality, very good; season, early.

Foster.

This variety originated with Mr. C. H. Foster, of Manatee County, Fla., as a chance seedling grown from seed brought from Havana, Cuba. As a very early orange it is especially desirable. The original tree, now about forty years old, is said to be productive, and a well-beaten path to it attests the esteem in which the fruit is held. The following description of the fruit was made from specimens sent me by Mr. P. W. Reasoner, of Manatee:

Size, medium, 3 inches; shape, round or nearly so; color, pale orange; skin, smooth, thin; core, medium to large; seeds, numerous, elongated; flesh, light-colored, juicy; flavor, mild, pleasant, but not very rich; quality, good, but not best; season, very early, specimens received from Manatee, Fla., fully ripe on September 10, 1887.

King.

This orange was introduced from Cochin China, in 1882, by Dr. R. Magee, of Riverside, Cal. It has been grown in California and Florida by a very few persons, and the fruit is esteemed by those who know it best. I have frequently tested it, and have also recently seen the tree in bearing on the grounds of J. E. Cutter, at Riverside, Cal. The tree, although of upright growth, is rather ragged in appearance. The leaves are dark, and the branches thorny. On the whole, I do not like the tree. The fruit partially resembles the mandarin orange and may be described as follows:

Size, small to medium, 2 to 3 inches in diameter; shape, flat, wrinkled and drawn to a point at the stem; color, dark orange; skin, rough, rather thin, parting easily from the flesh; core, rather small, open; seeds, numerous, round; flesh, dark, sections part easily, juicy; flavor, very sprightly, tart; quality, good; season, late; received from Riverside, Cal., in good condition June 20, 1887.

Konah.

The history of this orange I have from Mr. A. P. Combs, of Riverside, Cal., who states as follows:

About the year 1866 J. DeBarth Shorb, of San Gabriel, Los Angeles County, had a very fine orange sent to him from the island of Konah, in the Pacific Ocean. He

planted the seeds, and raised from them two trees. One of them died, but the other did exceedingly well, and he propagated from it quite largely. It proved to be a very good orange and considerably above an ordinary seedling. It ripens about one month earlier than an ordinary seedling, is of a fine, rich, lively color, of good size, medium number of seeds, and, take it all in all, it is a first-class orange, but not equal to the Washington Navel, Mediterranean Sweet, Maltese Blood, or Paper-rind St. Michael.

From personal observation in the orchard of J. E. Cutter, of Riverside, I know the tree to be a handsome, upright grower, productive and thornless. The leaves are very pale green; the fruit is of medium size, about three inches; in shape almost round, but inclining a very little to oblong; skin, rather smooth, of pale color and thin; Core, medium, sometimes a little hollow; seeds, numerous, well developed, but usually pointed at both ends; flesh, pale colored, very juicy; flavor, mild, pleasant, but not rich; quality, very fair.

Hart's Late.

(Synonym, Hart's Tardiff.)

The origin of this orange is uncertain. The first positive knowledge of it is that S. B. Parsons, of Flushing, Long Island, about 1875, took it from his greenhouses on Long Island to his nursery near Palatka, Fla. He thinks it came to him from Thomas Rivers, of England. Edmund H. Hart, of Federal Point, Fla., got it from Mr. Parsons's nursery, and it was in his hands that the real value of the variety first came into public notice. On the 25th of April, 1877, the fruit was first brought before the meeting of the Florida Fruit Growers' Association by Mr. E. H. Hart, and "it was found unripe and unpleasantly acid." On June 13 of the present year (1887) Mr. Hart sent specimens to this office which were in prime eating condition.

Size, medium, about 3 inches; shape, oblong, a little tapering towards the stem, which is set in a slight depression; skin, rather thin, a little roughened, deep pits on surface; color, bright orange; core, medium, quite firm; seeds, numerous, rather slender, pointed; flesh, light colored, very juicy; flavor, a pleasing combination of sweet and acid; quality, very good; season, very late, from May to July in Florida.

Washington Navel.

(Synonyms, Bahia, Riverside Navel.)

This orange was illustrated in my report of last year, and a brief history of it there given. The name Bahia which was then used is that which has the prior claim, but as I stated in that report, Washington Navel has become so much more commonly used instead that the old name which Mr. Saunders, of this Department, gave it is forced to give way. There has been so much interest shown within the last year regarding the origin and bearing qualities of this variety by the fruit-growers of the orange regions, and it is of so much practical importance that I have taken special pains to investigate the entire subject.

As a result I have to say, that the twelve orange trees which Mr. Saunders, as superintendent of the gardens and grounds of this Department, imported from Bahia, in Brazil, were all of the same variety. After examining the original trees yet in the orange-house

here and testing their fruit, and that of their progeny grown in many places in Florida and California, and after reading with care nearly all that has been published in the papers on the subject, I am convinced of the truth of the above statement. It is claimed by some that the two trees (some ignorantly say one,) sent Mrs. L. C. Tibbetts, of Riverside, Cal., were a part of the original imported twelve and that they were a different variety from the rest. This is a mistake. These trees were propagated from the original twelve and were sent to Mrs. Tibbetts in 1873, which was three years after the importation occurred. Since submitting my former report I have visited the two trees and gathered and ate fruit off them. They each bear fruit alike in character, and identical with that sent me from many places in Florida and California under the two names above mentioned, and similar to that produced on the old trees here at Washington.

The name Riverside Navel was applied to it in California, because the first fruit produced in that State was at Riverside and on these two trees.

In regard to productiveness I have conflicting reports. In Florida it is in many cases reported as being fruitful enough, but more frequently the reverse. At Riverside I examined many bearing orchards of this variety, and almost always found the trees well loaded. Commercial growers there told me that their Washington Navel trees bore quite well enough. In the number of oranges on a tree it is not equal to most other kinds, but the extra size and quality of the fruit and extra price obtained is thought to fully make up for the lack in number.

Although the trees bloom very abundantly, and in most cases the fruit sets well, it drops badly soon after setting. Why this occurs is a query. After tedious examination of the anthers of the flowers of this and many other and more fruitful varieties under the microscope, taken from the trees here, and those sent from Florida and California, with a view to discover the absence or presence of pollen, I am convinced that the Washington Navel has almost no pollen. The naked eye shows a marked difference; for instead of being yellow with pollen grains, as the anthers of most varieties are, they are white; and by the aid of a powerful mocroscope only now and then a grain of partially-developed pollen was found. Whether or not this is the cause of its shy bearing is not certain, for there are supposed to be plenty of grains from other varieties floating in the air sufficient to pollenize the stigmas of its flowers.

This variety being almost entirely seedless, it may be thought to be the result of the lack of pollen. The peculiar umbilical mark at the blossom end of the orange, which gives the name "Navel," is rather singular. There are, however, other "Navel" oranges which always have this mark, and the same peculiar feature is occasionally noticed in many varieties. This is an abnormal characteristic, or monstrosity, which seems to me a sort of secondary orange just at the apex of the fruit, or an additional placenta running the length of the whole fruit, but larger at the end opposite the stem. It will take much additional experiment and study before any safe conclusions can be reached on this whole subject. The co-operation of all interested persons is earnestly desired.

THE POMELO (synonym, Grape Fruit).

(*Citrus pomelanus.*)

Although closely related to the shaddock, this is a fruit of excellent quality. It ripens mainly after the orange is gone and is then highly esteemed. Florida produces the best in quality and almost the entire amount grown. In the northern markets it is becoming popular and will be a very profitable crop to grow. The flavor is quite peculiar. It is somewhat bitter, but withal very agreeable, especially after a second or third trial. There is to my mind no more wholesome and refreshing fruit for dessert use during the spring and summer. It should be eaten by cutting the fruit in halves crosswise and using a spoon to avoid the bitter taste of the rind.

Most varieties are of large size, often 5 inches or more in diameter, and nearly round, being slightly flattened at the stem and blossom ends. The color is uniformly a light yellow. The name "grape fruit" was given to it from the fact that the fruits hang so closely along the branches as to crowd each other and in the distance look like huge clusters of yellow grapes; but the name is otherwise so inappropriate that I have decided to use *pomelo* instead, which name is, however, less used than the former.

THE KAKI* (or Japan Persimmon).

(*Diospyros kaki.*)

So far as I have learned the first trees of *Diospyros kaki* grown in North America were from seeds obtained and sent by Commodore Perry, of the U. S. Navy, to Lieutenant Maury, in 1856, and were planted at the Naval Observatory at Washington. The first fruit was produced on these trees in 1860. None of these seedlings, so far as known, were distributed or any of their progeny, and the old trees are now dead.

The next introduction of this species was by a lot of seeds imported from Japan by Mr. William Saunders, of the United States Department of Agriculture, in 1863. They were planted on the grounds of the Department and germinated freely, and a part of the seedlings were sent out for trial. Some of the original trees grew to bearing size, and in at least one case produced about a bushel of fruit on a single tree, but all of these older trees on the grounds of the Department are now dead. Owing to the crude state of pomology in Japan it was almost impossible to get grafted trees until about the year 1870, when the Department of Agriculture imported a lot of grafted trees of named varieties. These were distributed all over the United States, but principally in California and the Gulf States. The nomenclature of these varieties was very imperfect, many trees being without name, some with dual names, and different varieties with the same name, as subsequent experience has proven.

At the present time (1887) great difficulty is experienced in identifying the varieties of this fruit; but in response to my requests a large number of specimens were this year sent here for study and comparison. These were from Georgia, Florida, Alabama, Louisiana,

*Pronounced Kahkee.

Texas, and California. The names attached to the same variety were only in a few cases the same. Generally no names were given, or those evidently wrong, and scarcely a person sending them laid claim to their correctness. Great pains were taken in studying and comparing these specimens with each other and with the best original drawings and paintings of the named varieties of kaki made in Japan by native artists. This work is to be vigorously prosecuted the coming year (1888), and I trust that all persons who have bearing trees will send specimens here, and thus assist in carrying it forward.

As the result of these investigations three varieties—Hachiya, Tane-Nashi, and Yemon—have been quite clearly identified and are illustrated on Plates 2 and 3 of this report. Their size and shape are exactly given, and their color as nearly as could be copied.

A great many of the trees sent out by this Department (which included many of the first seedlings grown by Mr. Saunders) died from being planted in too cold a climate, and some that were planted where they ought to have done well were very much neglected and, having done poorly, created little interest. But some of them, under more favorable circumstances of both climate and culture, produced excellent results, and the nurserymen of the country began to import and sell trees. New seedling varieties are now being originated in the Southern States, and some are of excellent quality. It is hoped to cross this species with our native persimmon and thus get kinds that will be hardy and bear large fruit.

After repeated trials all over the United States it is now known that the species will not thrive in a climate where the temperature falls to zero even occasionally, and some varieties are still more tender, as there is considerable difference in the varieties as to hardiness. The northern limit of successful growth is about like that of the fig, being on a line with Charleston, S. C., southern Tennessee, and northern Texas, but extending several degrees farther north along the Atlantic and Pacific coasts. Georgia, Florida, the Gulf States, and California seem well adapted to its culture, and by experienced travelers in Japan is said to do better here than there, the fruit here being larger, fairer looking, and of better quality. In California the fruit does not seem to be as large or as luscious as that grown this side the Rocky Mountains, and is not thought so highly of in that State. This is, perhaps, owing to the dry climate. The tree is a more luxuriant grower than our native species, *D. virginiana*, and makes a handsome ornamental tree, with large, glossy leaves.

After another year's observation I have determined that the flowers are sometimes perfect and sometimes the stamens are abortive. The perfect flowers are always found in the axils of the leaves and always solitary. The imperfect flowers are sometimes found in clusters. The species may be said to be diœciously polygamous.

The fruit, in size, is from 1½ to 3½ inches in diameter, and an occasional specimen has been known to weigh 20 ounces. In shape it varies from flat to round and oblong-conic. In color it is from chrome-yellow to bright orange-red, the latter being the most common. In flavor it is very sweet and the pulp is usually very soft. There is, however, considerable variation in both these respects. Some of the varieties require frost to make them at all palatable or before their natural acridity will leave them. Others are never acrid in any stage of their growth. Many kinds are entirely seedless.

As a fruit it is steadily winning its way into the markets of our larger cities and may occasionally be found on the fruit stands of

our large cities in the North. Up to this date there has been but little of the fruit to sell. The largest amount grown by any one person or firm of which I have heard was by Mr. J. Crawshaw & Son, of Lawtey, Fla. I have been informed that the past year they sold about 100 bushels, principally in New York City, at an average price of about $7 per bushel. The fruit ships remarkably well, as it should be picked a little before it is ripe, and can then be transported with perfect safety for thousands of miles. It matures and softens very gradually, and makes an excellent fruit to handle by retail dealers. It has an additional advantage in being very attractive in appearance.

*Hachiya.**

This variety grows to the largest size of any I have yet seen. The shape is oblong-conic, dropping off rather abruptly to a point. Many specimens are decidedly quadrangular. The color is a dull yellowish scarlet, with small dots, and occasional blotches of a brownish cast, generally found more numerous near the apex.

The flesh is rather firm and of a dull color, with reddish streaks running through it lengthwise of the fruit. Seeds rather numerous and very long and slender. The flavor is sweet when fully matured, but quite astringent when only partially ripe. The quality is below that of some varieties. It is one of the principal varieties used for drying in Japan. The illustration (see Plate 2) was made from a specimen from Lyman Phelps, of Sanford, Fla.

Tane-Nashi.†

Size, large to very large, some specimens having a diameter of 3 inches. The shape is roundish conical, or heart-shaped, and very symmetrical, there being no approach to quadrangular, as in some others; scarcely any cavity at the base, and stem one-half inch long. Color, bright orange-red, without any mixture of dull shades. The flesh is quite soft and in flavor a rich sweet; astringent before full maturity. It is without seeds. This is another of the varieties commonly dried in Japan. It bears well and is, all things considered, one of the choicest varieties. When fully ripe the fruit looks like a ball of translucent jelly, and the taste does not belie its good looks. Specimens illustrated on Plate 2 are from O. P. Rooks, of Gardenia, Fla.

Yemon.

Size, medium, the diameter being from 2 to 3 inches; shape, flat, nearly always with four well-marked sides, and the same number of deep sutures running into a deep cavity, in which the stem and calyx are set. The point is a little depressed, and indistinct sutures run towards the four corners. The color is a bright scarlet. A delicate bloom covers the surface.

The flesh is of a dull chrome red, and when fully ripe so soft as to require a spoon to be used in eating it. The flavor is a most delicious sweet. It is quite generally thought to be one of the best in quality of any yet imported. This fact, together with its habit of

* Pronounced Hah-chee-yah.

† Pronounced Tah-na Nah-shee.

great fruitfulness and entire absence of seeds, makes it one of the best to grow.

The illustrations on Plate 3 were made from specimens from W. W. Thompson, of Smithville, Ga.

THE OLIVE.

(*Olea Europea.*)

One of the expensive articles of commerce that we of the United States have at present to buy abroad is olive oil. There are vast tracts in California, and possibly a few localities in other States where the olive will thrive. In fact it is now being planted extensively in California; in some cases as many as 40 acres or more in one orchard. Recently I had the pleasure of visiting some of these orchards. At the farm of Mr. Edward E. Goodrich, near San José, in that State, I saw the trees in bearing and the fruit being made into oil. Some of the trees had grown to nearly a foot in diameter and others were only just planted. This orchard and those of Mr. Elwood Cooper, of Santa Barbara, and Mr. Frank A. Kimball, of National City, the latter in the extreme southwestern county in the United States, are the largest yet planted. Mr. Luther Burbank, of Santa Rosa, is largely engaged in the propagation and sale of olive trees. It is my opinion that the best lands of the State for olive culture have not yet been planted. I refer to the foot-hills of the Sierra Nevada and other ranges lying back from the coast, and out of the way of the fogs and damp air nearer the ocean. The scale-insect, which is one of the pests of the olive, will not be likely to be troublesome there, and there is plenty of cheap land to be had, which in California is a desideratum. The rather elevated lands where frost will not be severe, and where the soil will not be so rich or moist as to induce a too rapid growth, will be the very best for this purpose.

Experiments are begun in olive culture in Florida, Texas, and other Southern States, but as yet no results worthy of report have been reached, except that the trees grow well.

Pickled olives are becoming more popular upon the tables of our people, and are very nutritious and wholesome. They are usually pickled while green, but to my taste those nearly ripe are much more palatable and also more nutritious. The fully ripe fruit in a raw and unpickled state is never eaten, possessing a very disagreeable bitter taste. The tree is very graceful and serves well the purposes of a street or shade tree.

The two varieties in general cultivation in California are described below:

Mission.

About one hundred and sixty years ago the Catholic fathers planted trees or seeds of the olive at the old mission of San Diego, now near the city of that name in California, which are yet standing and bearing, although entirely neglected. These trees are the origin of what is known in California as the "Mission" olive, and which is illustrated on Plate No. 6 in this report. The specimens from which this illustration was made were taken by me from the orchard of Mr. E. E. Goodrich, near San José, in Santa Clara County, and fairly represent the variety. It is thought to be one of the best known for pickling,

and produces an abundance of oil. Some growers do not consider it as prolific as some other varieties.

Picholine.

This variety was imported from France by the late B. B. Reading, with a number of others, and planted on his ranch near Sacramento, Cal., several years ago. All the others died, and after Mr. Reading's death it was propagated, supposing it to be a large-fruited variety. But the first fruit proved to be quite small. It ripens about six weeks earlier than the Mission and bears more abundantly and has smaller and narrower leaves. The tree has a compact, hardy, and vigorous growth and the cuttings root easily.

THE DATE.

(*Phœnix dactylifera.*)

No doubt many persons are ignorant of the fact that the date palm grows and bears fruit in several of the warmer parts of the United States. In Louisiana there were several bearing trees of this species, but the freeze of 1886 killed all but one of those in the city of New Orleans, and if any others are standing in that State I am not aware of it. In Florida there are many trees, but only a very few in bearing. The same is true of California.

I have no doubt but that the date will within a few years be successfully grown in limited sections of these States, and especially in California and Arizona, where a supply of water sufficient to keep the roots moist can be furnished. The conditions suitable to date culture are hot and dry air, and rich soil with abundant moisture in it. These conditions can be secured much better in a few valleys in the southern parts of Arizona and California than elsewhere in the United States. The air is quite torrid for months at a time, and the irrigation ditches will supply the water; but I do not expect that a sufficient quantity will be grown for many years to come to supply any considerable portion of the market demand.

Last October a cluster of ripe dates was received at this Department from Mr. O. F. Thornton, of Phœnix, Ariz., which was one of three borne by a tree seven years old from seed growing on the ranch of Col. F. C. Hatch, near that place. There were a number of seeds planted there by Mr. Culbertson in 1880, who afterwards sold the ranch on which they grew. This tree had also bloomed in 1885, but no fruit was matured as the bloom was cut off as a curiosity. Only one other tree besides this was preserved (the others having died in transplanting), and it fortunately is a male. The cluster contained 211 fruits of a chrome-yellow color, slightly tinged with bronze, and, all told, weighed 5 pounds. The seeds were perfect, and many of them were sent to Florida and have now grown into thrifty plants.

THE CRANBERRY.

(*Vaccinium macrocarpa.*)

Although the culture of the cranberry is from climatic reasons restricted to a small territory compared with its market range, it is by no means an insignificant fruit. It is wholesome and palatable to the consumer, and profitable to the grower where he has the right

kind of bog-land in the right climate, and has the necessary money, skill, and thought to devote to its culture.

Cape Cod, Mass., is perhaps the Mecca of the cranberry-grower. But there are good bogs in other of the New England States, and in New Jersey, Michigan, Wisconsin, Minnesota, and, I think, in portions of northern Oregon and Washington Territory also. The bogs of Alaska may prove to be of much value in this line, as the berry is reported to me as growing there in a wild state, and bearing well.

One thing we ought to develop, is the foreign trade in fresh cranberries and in the manufactured sauce. This belongs to the commercial tradesman, but the whole subject ought to be investigated and assistance rendered by our General Government wherever possible. This would add something to our export trade, and build up an industry remunerative to our people and harmful to no one.

Many varieties have been selected from the wild bogs, and are now cultivated and sold as are the plants of other fruits.

PROPAGATING NUT TREES.

The art of budding and grafting nut trees as practiced by nearly all persons is attended with many failures. Even in the hands of the most intelligent and skillful, it is no easy task. Just why this is so neither the scientist nor the practical operator may be able to say, but the fact remains a hindrance to those who wish to propagate the choice varieties of nuts, which is the only sure way to perpetuate the character of the fruit.

One plan which is found to work by some persons in the hickory, pecan, and some species of the walnut (*Juglans*) is what is called ring-budding. It is done in June when the bark "runs" or peels easily. Take cions from the size of a lead pencil to half an inch or more in diameter, with good healthy but dormant buds. From this cion take off a ring of bark from 1 to 2 inches long, including a strong, well-developed bud, using great care to in no wise bruise or even touch its inside surface. The branch or little seedling to be operated upon should be as near the same size of the cion as possible. Cut it back to a stump, and from this take out a ring of bark of exactly the same length as the one to be inserted. The ring from the cion is carefully split and placed on the stock, being sure that the split edges and the upper and lower ends join exactly. To do this and make the bark and wood fit closely, it may be necessary to take off a small strip of the bark from the edge of the ring. The greatest care must be used to have the work done neatly and quickly, lest the tender surfaces of the cambium are injured by rough handling or by long exposure to the air. Bind the whole securely with waxed cloth, leaving out the bud only. Some say to cover the whole, stump and all, with a paper sack until the union is perfected, tying it below the wound. Others think the cutting away of the top is not best until after the bud has "taken." If the work is not done in the best manner it will not be worth while to do it at all.

Common cleft grafting is also practiced, and other methods of grafting, too, both on small stocks at the surface of the ground and top-working. E. B. Engle & Son, of Marietta, Pa., have usually practiced cleft grafting on the chestnut with success. They find little difference whether the cions are cut in fall or spring. They have been quite successful with cions cut in the grafting season and

put on at once, even so late that the buds had swollen some. The waxing was done in the common way.

Others think that cutting the cions in the fall, and keeping them lying on the ground with just enough covering of leaves or other loose material to prevent evaporation until late in the spring, is quite essential, thus retarding their growth until the sap starts in the stocks.

Reports of experiments with all these methods are earnestly desired.

REMARKS.

In addition to the foregoing described varieties of fruits there have been received at this office hundreds of packages, varying in size and amount from one specimen to a barrelful containing many varieties. I wish to acknowledge the deep interest in the work of this division that has been manifested by thousands of fruit-growers of the country, who have sent specimens and information of a pomological nature. The above-mentioned packages contained fruits of almost every kind known to this country, from the banana, mango, sapodilla, date, and lemon of the most southern regions, to the crab-apple, the dwarf blueberry, and cranberry of the north. Alaska and several foreign countries have also contributed. It is highly gratifying to have such hearty co-operation in my efforts to serve the cause of pomology. It is moreover a matter of extreme gratification to me to have had many official demonstrations of your own interest in this work, and I sincerely trust that whatever has been done or may yet be done by this division shall result in the advancement of the interests of those who are producing and consuming our fruits.

Obediently yours,

H. E. VAN DEMAN,
Pomologist.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

PEACH CULTURE IN THE EXTREME SOUTHWEST.

[Report of G. Onderdonk, special agent, U. S. Department of Agriculture, Division of Pomology.]

SIR: In submitting my report concerning the pomological interests of the Southwest it seems needful to present a preliminary statement of distinctions required in dealing with the fruit interests of not only the Southwest but of the extreme South generally.

While the farmers of every section have recognized the fact that certain crops are adapted to certain zones, and even that certain varieties in each general class of products are inexorably confined to limits presenting the required special conditions, yet it is marvelous to behold to what extent the pomologists of the United States have practically ignored this principle in its application to their work, thus entailing upon themselves and those dependent upon them in various relations losses so ruinous in extent and multiplied in variety of character. It has been too largely assumed that in the planting and care of the different fruits it was only necessary to decide what *variety* was desired in order to suit the purpose of the planter, and then to plant that chosen variety, without reference to climatic conditions. This is a great mistake.

Applying this thought to fruit culture, we observe that our people of every latitude have acted too much upon the supposition that they have only to determine the variety of peach desired and then plant that variety, regardless of the zone in which it is situated, and utterly ignoring the thought that there are different classes of the great peach family, each belonging by nature to its own isothermal zone, and refusing to remunerate the care bestowed upon it when subjected to the conditions of an unfriendly climate. And nowhere has this mistake proven more disastrous

than in the extreme South and Southwest. Observation and the dearest of all teachers, experience, teaches that while the fruits may be subjected to largely varied conditions, yet the stern hand of nature has fixed her bounds, beyond which human persistence can not force its way.

We are compelled to recognize that there are not only special strains of peaches, but that there are distinctions more obstinate than those of mere strain, which we can hardly define without the use of a term no less comprehensive than the designation of *race*. While we may deprecate the multiplication of distinction and the interests of peach culture in the higher latitudes have not required an observance of the distinctions of *race*, because only a single race has been comprehended there in the entire range of peach culture, yet when we come to investigate the peach in lower latitudes, nature forces her classifications upon us with a perseverance that admits of no denial.

We are aware that our declaration of several types of peaches so distinct as to be entitled to the designation of the races will be met with criticism by some more Northern minds. But in the extreme South, where different races come into part competition, the necessity of recognizing the distinctions made by the hand of nature is forced upon men of practical experience. Nature seems to have assigned to each race special conditions, and therefore special zones. We find that while a single race (the Persian) occupies the northern extreme, and another race (the Peen-to) occupies the southern extreme of the general fruit zone, yet the intermediate zones of the different races so overlap each other that in some cases two or more different races are found successful upon ground common to each other.

In defining the different races it is quite impossible to avoid the use of terms that are not more or less arbitrary. And yet we must have names to identify things. Should we employ any names in our designations of the races of the peach that are illy applied we shall be glad to have them substituted by designations more fitting.

THE PERSIAN RACE.

This race includes all varieties springing from the importation from Persia to Italy during the reign of the Emperor Claudius, which was introduced into Great Britain about 1550, and to the American colonies about 1680. They are all late bloomers and can not carry their foliage through the growing season of the southern portion of the belt in which they are cultivated. This race includes the varieties usually propagated in the northern nurseries and composes the bulk of the northern orchards. By designating this race of peaches as Persian there is no intimation that *all* peaches are not of primal Asiatic origin. But as the history of this race is universally conceded, there can be no question of the propriety of giving it a name referring it to the country of its origin.

We refer to the accompanying diagram, representing the relative position of the different races with reference to the isothermal lines. In Texas this race seems successful as far down as Palestine and at some elevated points below. The identification of the isothermal lines bounding these various zones would be a matter of practical interest to our people.

THE NORTHERN CHINESE RACE.

This race, as far as we have become acquainted with it, consists of the Chinese Cling and its numerous progeny. It does not seem to exist in great perfection in the northern portion of the general peach zone. It attains its greatest perfection in the latitude of northern Texas, and flourishes nearer the coast of Texas than the Persian varieties. It succeds well as far southward as Austin, while below that point it diminishes in productiveness and longevity till a little below Gonzales; most of its varieties become worthless. We would expect it to succeed everywhere in the zone corresponding with the one indicated by the places in Texas which we have named. Some of its varieties (notably the Thurber) creep still farther south under the influence of a moist atmosphere. It might be remarked here that there are found to be notable instances in which a humid atmosphere causes fruits to flourish below what would otherwise have been their limit.

The Northern Chinese race is remarkable for the great size of its fruit, as well as the peculiar almond-like appearance of its foliage, so peculiar also to the Southern Chinese race of peaches. Judging from what we can see of the Chinese peaches in the United States, we might conclude that there is quite as much contrast in China between their northern and southern types as we can observe in the great peach belt of our country.

THE SPANISH RACE.

We have been calling this race Spanish because we could not trace its history with any certainty farther than Spain. It appears to have been introduced from Spain to Mexico some two hundred and fifty years ago by the Catholic missionaries. It seems to have come to Florida in a similar way. It has been so long cultivated from seed in southern climates that it has become developed into a distinct race. The varieties of this race are mostly early bloomers, and they continue to grow throughout the long Southern season till interrupted by the comparative cold of our winters. This race has become widely scattered in the Gulf States and constitutes a hardy race of seedlings which have become the foundation of many choice varieties, corresponding closely in quality and appearance of fruit with some of the standard varieties of the Persian race. Prior to the introduction of the southern Chinese race into the extreme South, the Spanish race supplied the only possibility of successful peach orchards in the coast region of the Gulf. The relative isothermal position of this race will be seen by reference to the accompanying diagram.

THE SOUTHERN CHINESE RACE.

This race, as far as it is now represented in the United States, consists of the Honey peach and its progeny. Mr. Charles Downing, of New York, obtained some seed from China, and the original Honey tree seems to have been the only result of this lot of seed. The high latitude in which Mr. Downing lived was so unfavorable to the race that the original tree never fruited. But a budded tree was given to Mr. Henry Lyons, of Columbia, S. C., about 1855. The variety was placed in the hands of Mr. P. J. Berckmans, of Augusta, Ga., and the entire stock was held by him until 1858, when it was sent out for the first time; but it was not of superior value at Augusta, being still above its proper zone. When it was tried in Florida and in southern Texas it was found to be of very special merit; it ripens a little before the Tillotson. Several seedlings have been produced from it of special value to the extreme South, where the early varieties of the Persian race range from uncertain to impossible, according to the thermal conditions of the locality. This race supplies our hardiest trees in the coast country of Texas and will always bear well, however mild the preceding winter. This race is not valuable in extreme north Texas. I have not obtained its proper northern limit, but have represented its zone on the diagram as falling a little short of that of the Persian race.

THE PEEN-TO RACE.

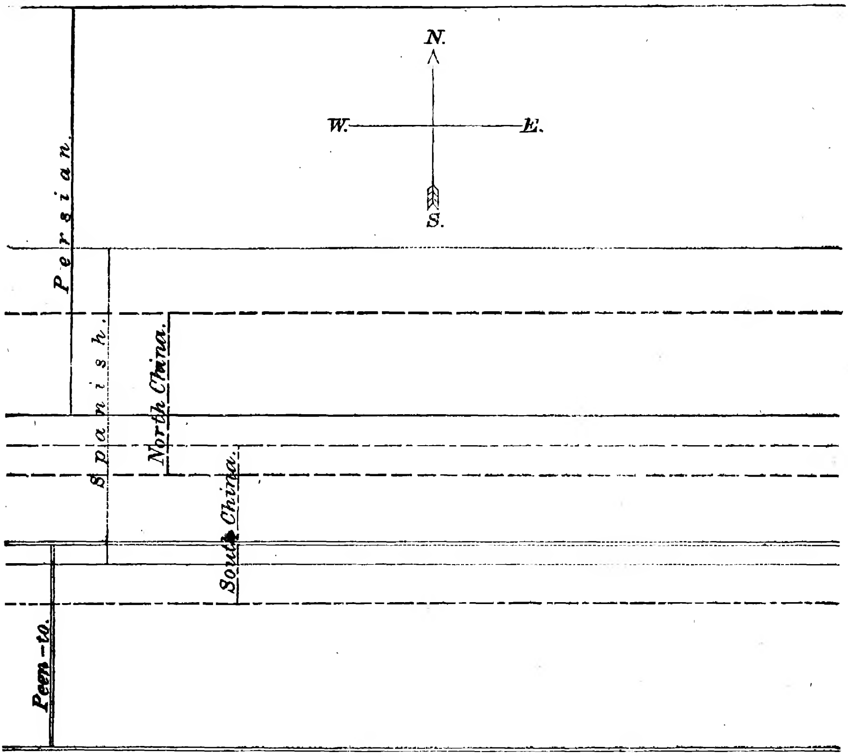
This race was intoduced by Mr. P. J. Berckmans, of Augusta, Ga. He imported the pits from Australia in 1859. It was found worthless at Augusta, being above its proper zone; but it has been found of decided value in Florida. In the coast region of Texas generally the fruit of the Peen-to is mostly lost on account of its extremely early blooming. In southern Louisiana and in our extreme Southwest, at Brownsville, Tex., it promises better and may be found valuable. In general terms, I should say, after watching the Peen-to for a number of years, that in southern Texas generally this race is yet too far north to be successful, and belongs below the isothermal lines of 70°. Several seedlings of this race have been obtained which seem to be of great value only when far enough south to be in an orange-growing country. In fact, it would be interesting to see how far south of the zone of any other type this race might flourish.

There are some hybrids beween the Peen-to and south Chinese type which promise highly. This race will undoubtedly prove to be a tropical type of peaches, fully at home among the oranges, lemons, bananas, pine-apples, guavas, and cocoa-nuts.

SUPPLEMENTARY.

A survey of the limits of the different zones embraced in our general peach belt presents to the mind the interesting conclusion that, if the proper races are selected as material, peach culture is possible in every latitude of our great country, from the Great Lakes to our extreme Southern limits.

Chart showing relative situation of the zones of the different races of peaches in the United States.



GRAPE CULTURE.

My observations upon the subject of grape culture in the extreme Southwest have extended through a period of thirty years. I have planted of every family of grapes known to our horticulturists, and carefully watched the results. I have closely observed the plantings of others, and the comparisons which I have been able to make during the present year have added confirmation to the generalizations that have been developing for some years.

Nothing seems more certain than the fact that generalizations governing the location of the different races of the peach have a parallel in viticulture. Yet it seems that the modifications resulting from variations in the degree of humidity are more marked in grape culture.

During my investigations of the present year I visited the vineyard of Mr. Hatch, at Ingleside, near Corpus Christi, Tex. While no variety of *V. labrusca* or *V. rotundifolia* has been of any considerable duration anywhere in the general region, it being the zone of the Herbemont type and *V. candicans*, yet I there saw different varieties of *V. labrusca* and various hybrids, all growing in the utmost perfection among those of the Herbemont type. A single Scuppernong covered a space of not less than 3,000 feet and in full bearing. Mr. Hatch's vineyard is situated upon a peninsula, with some miles of water on three sides, and the Gulf also supplying vapor for the region. The entire site is composed of sand to a great depth, perhaps 30 feet. The success of these varieties may probably be attributed to modifications by the humidity of the local atmosphere, as the same varieties failed in similar soil at other places.

In the vineyards of Corpus Christi, the soils varying, there was a general sameness of results in reference to the classes of grapes. In the vineyard of Mr. John

McCampbell, 2 miles back of Corpus Christi, on elevated ground, where inland influences prevail the varieties of *V. labrusca* were a failure. His best success is with varieties of the Herbemont type. In all of these vineyards there are several varieties of *V. vinifera* growing in great luxuriance and productiveness. Unfortunately few cultivators have a correct nomenclature for their grapes. There seems to be no phylloxera in that region.

In the vineyard of Mr. Hatch at Ingleside the *V. vinifera* are said to ripen well on an average of about every alternate year. Of the remaining crops the loss from rot varies from 20 per cent. to total, while under more inland influences the rot is less severe. The decay seems to depend upon the amount of dew or rain during the ripening season.

It is interesting to note that the very loose sand of Ingleside is such that phylloxera can not work in it, and therefore a whole section of about 25 square miles may be expected to be always proof against phylloxera. The bearing of this fact upon the value of the locality for the production of raisins is interesting to the country, as phylloxera will no doubt finally infest every soil of the country suited to their presence. It is also an encouraging reflection that the varieties of *V. vinifera* that may be found generally suited to the climate can probably be preserved upon stocks of the *V. rupestris*, which is indigenous to portions of Texas.

At Point Isabella and Brownsville, varieties of the European type were formerly successful. But now these varieties are all either dead or in a dying condition in every case which I could find, while Lenoir and Herbemont (both proof against phylloxera) flourish in perfection. It was inferred from appearances that the *V. vinifera* died from phylloxera, but I did not have lenses to investigate closely. At Matamoras the same state of grape culture exists.

At Laredo, Tex., I examined many plantations of grapes. I found *V. vinifera* varieties composing the bulk of the plantings there. The few plantings of Herbemont type were entirely promising. The growth of these two classes is vigorous and the plants productive. There appeared no evidence of phylloxera at Laredo. This is a high region with the atmospheric condition of the arid country around it.

V. vinifera and Herbemont types represent all of the successful plantings at Laredo. I saw many plantings of different types, which were evident failures.

Whatever may in the future be supplied to southwestern Texas from combinations between indigenous classes or classes that may prove adapted it is very plain that, aside from varieties of the *V. vinifera* and Herbemont types, we have nothing now that will give success in the extreme Southwest except under local conditions. The Herbemont and Lenoir, both of which are purely wine grapes, seem better adapted and hardier than any other varieties. In fact these varieties succeed in the utmost perfection and make of nearly the entire State of Texas a natural wine-producing region of enormous capacity, if it should ever be developed in that direction. Of these two varieties the Lenoir attains its greatest success in the southwest, and will probably not prove successful in northern Texas, while the Herbemont region seems to cover the entire State. There are a number of new seedlings of this type, also others of various combinations now on trial, which present possibilities of vast service in the future.

Respectfully submitted.

G. ONDERDONK,
Special Agent.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

KELSEY.

SATSUMA.

W. H. PRESTELE, FECIT.

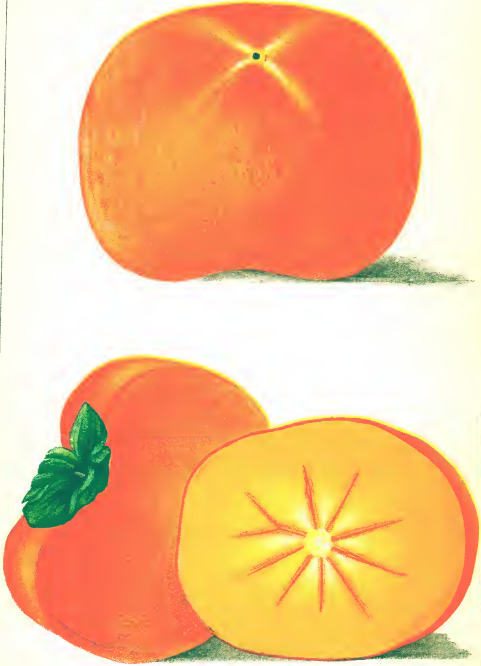
GILES LITHO & LIBERTY PRINTING CO. N.Y.

HACHIYA.

TANE-NASHI.

W. H. PRESTELE, FECIT.

SUESS LITHO & LIBERTY PRINTING CO N.Y.



YEMON.

W H PRESTELE, FECIT

W. H. PRESTELE, FECIT

THE HATCH LITHO CO. N.Y.

SUMMER ROSE

W H PRESTELE DEL. HATCH LITHO CO N Y

SATSUMA

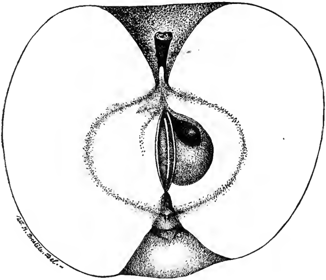
Synonym Unshiu or Oonshiu

W H PRESTELE FECIT

HATCH LITHO CO N Y

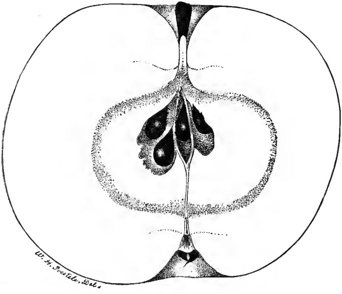
"MISSION" OLIVE.

Fig. 1.



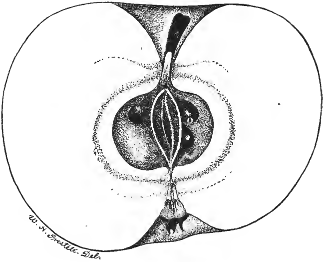
OZARK.

Fig. 2.



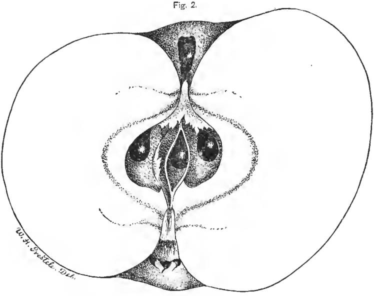
BELLA.

Fig. 1.



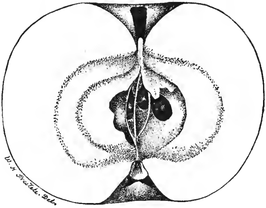
STAR.

Fig. 2.



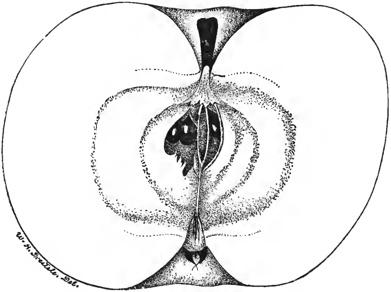
HUNTSMAN.

Fig. 1.



HARBOUR.

Fig. 2.



ORANGE WINTER.

REPORT OF CHIEF OF SEED DIVISION.

SIR: In presenting my third annual report I am able to announce progress in the direction of efficiency and usefulness. For this I am indebted to your practical suggestions and hearty co-operation, as well as that of my assistants, who have manifested a lively interest in making my Division a creditable one in one of the most important Departments of the governmental service.

The system of testing the seeds which has now been in successful operation for more than two years is all that is to be desired in that direction. As a result of this, the amount of worthless and sterile seeds offered for sale to the Department for distribution by this Division has become so small as to be hardly appreciable.

This, together with the strong guaranty now required of those who furnish seeds to the Department, has effected the most desirable results, for it is an indisputable fact that a better class of seeds has never been disseminated than that which is now being distributed annually. The following quotations from a few of the many recipients of them in all parts of the country are but a fair sample from the many hundreds of reports that are received each year:

"When I compare the vegetables that are now in our market with the market forty years ago there is a marked difference, and I believe the distribution of seeds by the Government has been a potent factor in making the difference."

"We have found all seeds sent to us from your Department exceptionally clean and of good germinating qualities."

"All seeds received from the Department have germinated well and proved true to description. I consider the distribution of great value to this country, as it places new and desirable varieties in the hands of people in different localities."

"The garden seeds received from you compare favorably with those received from our best seedsmen, and possess the advantage of being more certain to germinate."

"I am confident the system of distribution by the Department of Agriculture has not only introduced many new and valuable varieties but has been the means of improving standard seeds."

"There is no doubt as to the practical value of the Department of Agriculture to the farming interests of the nation."

A prominent agricultural writer, in speaking of the benefit of the seed distribution, says:

A great deal of good has been done by the Department of Agriculture. The introduction of the Sorghum plant is a noticeable example, for the value of the crop, according to the census of 1880, was $11,000,000. Scores of varieties of most excellent seeds have been put within the reach of the masses of the people, who would not otherwise have obtained them because of the exorbitant prices charged for them by unscrupulous dealers who have been among the first to condemn the Agricultural Department.

The business of the Seed Division is to receive, keep a correct and classified list of seeds; to subject these to a double test before accepting them; to store away systematically all the seeds purchased; to receive and care for all the miscellaneous supplies needed in putting up and distributing the same; to make paper pockets and cotton bags

for the reception of seeds; to estimate the number of the same requisite for each variety; to prepare copy for seed-pocket labels, comprising the name of seed, and, when deemed necessary, directions for planting and cultivation;* to put up seeds in quantities suitable for distribution; to prepare large numbers of packages of the various kinds to meet any exigency that may arise; to fill, as received from the Commissioner or chief clerk of the Department, the orders of Senators, Representatives, and Delegates in Congress; to address the required number of franks and postal cards; send seeds to about 4,200 State and county statistical agents of the Department, to agricultural colleges and experiment stations, agricultural societies, and to miscellaneous applicants throughout the entire country, and to such persons in foreign countries as desire to effect exchanges with this Department; to keep sets of books in which entries in detail are made of all seeds received and of all distributions (with the exception of those to members of Congress); to make up at the end of each fiscal year an alphabetically arranged statement showing in full the quantities, species, and varieties of seeds received by the Division during the year, as well as preparing a tabulated statement showing the distribution of seeds during the same period; and to do much other necessary work of such a character as not to be easily classed under any particular head, but none the less essential to the usefulness and efficiency of the Division.

Seed growing having become an important industry of the United States it has become a necessity that seed cultivators should know something of the habitat of the seeds with which they experiment, for if seeds be grown in a latitude unsuited to them, failure will be the invariable result. We know the effort to acclimatize the olive, fig, and banana in the open air where the thermometer falls below zero has always resulted in the loss of the plants. Different localities often seem best adapted to different varieties of the same family, as is apparent in the grasses. Timothy grass is grown largely in Illinois, Wisconsin, and New York; Red Clover in Michigan, Ohio, and Indiana; Lucerne or Alfalfa mainly in California, while Blue Grass and Kentucky are so closely associated that the mention of the one suggests the other. The problem of acclimating varieties must necessarily be one of slow growth, inasmuch as mere examination of seeds can never take the place or afford the certainty of practical experiment.

For this and many other reasons there is a pressing need for greater unity of action among practical scientific agriculturists throughout our country. Not only would time and labor be saved, but better results would be obtained with concert of action. Science with practice will be sure to achieve results immeasurably greater than would either, unaided by the other. A correspondent residing in southern Texas, in a recent letter to the Department, says in regard to the value of Northern seeds for planting in the South:

> One thing I have learned, and that is, that the farther north we can procure our seed corn or other seeds the earlier the crop will mature. For instance, seed corn will mature thirty-eight days earlier from seed grown in Ohio than from seed of the same variety procured from Mexico.

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*A complaint has justly been made to this Department that no directions accompanied the packages of seed of the Russian forage plants, whether the seeds should be sown broadcast or drilled in and cultivated. An earnest though unsuccessful effort was made to procure the desired information in time for the spring distribution.

Seed is the foundation of farming, and good seed of good farming. All seeds should be tested both for vitality and purity. It is a fact well known by practical seedsmen that a very small percentage of impure seeds means very many in a bushel.

In the last decade a new impetus has been given to the agricultural interests of our country. Our Southern farmers and the new settlers of our Western Territories have awakened to the necessity of utilizing more fully the great advantages we possess in soil, climate, and productiveness. The question as to what seeds are best adapted to different localities, even in the same latitude, but affected by various altitudes, winds, and ocean currents, is becoming one of no small importance, and points to the practical benefit of judicious care in the selection of seeds to be planted and great watchfulness as to results.

This is most fully illustrated in the case of Florida. All of Florida lying south of the twenty-ninth parallel is in a belt of northeasterly winds and can not therefore be included with even Georgia, Alabama, Mississippi, and Louisiana in climatic conditions or productions. The inference from observation connected with these facts is, that food and fodder plants for this section must be sought and found in countries having climatic conditions similar to its own.

It is believed from these climatic comparisons that Florida, the arid portions of southern Texas, and southern California must look to Egypt, India, and Japan for vegetable stock. The Department has and can aid materially in being able to furnish these new and valuable seeds for experiment in localities seemingly adapted to their successful cultivation. The Government holds it in its power to do this, where private enterprise would fail for want of means or requisite information on the subject. In furtherance of this design and in accordance with the law establishing the Department of Agriculture for the purchase and distribution of such seeds as are "rare or uncommon to the country" substantial progress has been made by the Department.

The farmers in western Texas are earnestly endeavoring to find grains that will germinate, grow, and mature with the smallest amount of water, which, though limited to 10 or 15 inches of rainfall each year, may yet be made a growing quantity. The great question now being asked by this growing section of country is how to use sunshine and rain to the best interest of the farmer. By means of the cordial co-operation of the Botanist of the Department with this Division, seconded by the earnest efforts of the Commissioner, a measurable degree of success has attended the procuring and introduction of several new and valuable grasses for both summer and winter grazing on some of these half-barren plains, where, without suitable grasses, agriculture must necessarily be neglected and progress retarded.

In the solution of an agricultural problem of so much importance in a country extending through so wide a range of latitude, a climate so diversified, and with agricultural interests the greatest in the world, the Department of Agriculture must ever be an important factor.

The tendency to place all sorts of vegetable seeds upon the market under new names will continue until some system shall be inaugurated conjointly by the creation of a purely Agricultural Museum under the supervision of the Department of Agriculture and with

the co-operation of the directors of the Experiment Stations of the various States and Territories.

Without such a check, new names for old varieties unworthy of dissemination will continue to be increased, and extravagant notices of so-called new things will be continued. The primary object of the Department in procuring and distributing seeds is to substitute superior varieties for those which have deteriorated by reason of repeated planting in localities where each does not maintain its original vigor or standard of excellence. In this connection I desire again to call the attention of intelligent cultivators who may receive one or more varieties of seeds, to the importance of making a careful report of the adaptation of each to the locality and soil, with the view of furnishing the Seed Division of the Department of Agriculture with an array of facts of great practical interest for compilation and future reference, and for guidance in making purchases for subsequent distribution. This is one of the many reasons why all important facts connected with the cultivation of new varieties should be carefully noted, and the result (with name of variety) promptly reported early in the month of December of each year, in order that the deductions therefrom may be embodied in the annual report.

During the past year increased attention has been given to sending out blanks for reports on the merits or demerits of the most important and valuable seeds distributed from this Division. The replies to these queries are condensed and arranged according to varieties and localities and kept on file, thus enabling the Seed Division at any moment to furnish information upon seeds sent out by the Department. These reports for the present year have been in the highest degree satisfactory, and a growing desire is manifested from all parts of the country to obtain Department seeds, as being in every respect reliable. We would here call the attention of those sending such reports to the necessity of noting the names of the varieties received. Many reports that are highly satisfactory as to germination, quality, and productiveness of the seed can not be made available and are useless because the name of the variety is not given.

The Department still continues the system inaugurated some years since of exchanges of seeds with foreign countries, as has been shown by a former reference, and by this means useful and ornamental plants are procured and international courtesy fostered, for it is a noticeable fact that in the equitable interchange of seeds and plants which have taken place between our own Government and those of foreign countries our friendly relations therewith have been greatly strengthened and promoted. In no Department of the General Government has the expenditure of so small a sum been productive of so much good as that expended in the introduction and dissemination of valuable seeds and plants, thus verifying the French maxim, "Le don d'une plante utile me paraît plus précieux que la découverte d'une mine d'or, et un monument plus durable qu'une pyramide." ("The gift of a useful plant is much more precious than the discovery of a gold mine, and a monument more durable than a pyramid.")

Perhaps it may be safe to say that at no time since the establishment of the Department of Agriculture has the correspondence of the Seed Division been of more interest or of greater importance to the interests of agriculture than at the present time.

It embraces a wide field of inquiry, experiment, and facts, derived from both domestic and foreign sources. The accounts of experi-

ments with new or hitherto unknown varieties in forage, grain, tobacco, and cotton products become through its means the property of every intelligent farmer. The experiments with old varieties in new localities and the reports received from agricultural societies and individuals in every section of the country are of growing importance. The inquiries and replies from our consular agents in all parts of the world in regard to the new varieties of products which are now being so extensively introduced from Japan, Corea, and the islands of the sea, with the interesting accounts of their successful cultivation in the different sections of our own widely extended and rapidly developing country, embrace but a small part of the correspondence of the Seed Division.

We append some of the most interesting. The Persian Tobacco, which is now being disseminated, is produced in Hindostan and the provinces bordering on the Caspian Sea. It is highly esteemed and sought after by the wealthier class of Orientals for smoking through rose water, and is exported to Russia, and used in the manufacture of cigarettes.

The boom which Tobacco has taken in Florida in the past two years has created a great inquiry for good and new varieties of the weed. The Delli (or Sumatra) has been a variety for which there has been the greatest demand. This Tobacco is originally from Delli, a very large and populous colony of Sumatra. The Dutch authorities hoard it with jealous care, and it is difficult to obtain the seed for foreign growth. The tobacco from all the districts of the east coast of Sumatra goes into the market of the civilized world under the name of the Delli. The *Floridian*, of Tallahassee, Fla., published the following account of the result of growing tobacco in Leon County from Sumatra seed, sent from the Department of Agriculture at Washington for free distribution:

Last Saturday Mr. J. C. Shine brought to the *Floridian* office a single stalk, which was about as much as he could well carry, with a number of the largest leaves cut off. The plant was over 4 feet 10 inches high, and the leaves 29 inches long and over 13 inches broad. Many persons have examined this sample plant who know good tobacco when they see it, and all agreed that it was very fine and that they never saw tobacco equal to it. Mr. G. K. Clark, who comes from the famous Suffield tobacco section of Connecticut, says it eclipses anything he ever saw in the tobacco line.

The high prices demanded for the Sumatra tobacco have led to the formation of a company that has purchased large tracts of land in Florida and will go largely into tobacco growing next year. There is no reason why that State should not take a high stand among the tobacco-growing States of the nation.

REPORTS OF EXPERIMENT STATIONS, AGRICULTURAL COLLEGES' AND ASSOCIATIONS.

CEREALS.

CORN.

The White Giant Normandy gives excellent satisfaction from southern Alabama to northern Missouri. The Mosby produces finely from central Florida to central New York, on the Atlantic border, and also makes a wonderful yield in the Mississippi Valley. Pride of the North produces splendid crops in the Spring-Wheat growing districts as far north as central Wisconsin and southern Dakota. Yellow

Mammoth King is reported as being valuable in central Texas, in Iowa, and in northern Wisconsin.

California Agricultural College: The Mosby made a very fine growth and gave a heavy yield, the largest of several varieties tried this year.

Florida Agricultural College: The Mosby has a vigorous stalk, but the ears were not well filled.

Louisiana Experiment Station: The Mosby is a fine variety.

Mississippi Agricultural College: The Mosby is one of the best varieties with us when planted on good land.

Missouri Farmers' Club: The Pride of the North very early, and very valuable on this account in dry seasons.

North Carolina Lenoir Grange: The Mosby was excellent, very prolific, four or five ears to the stalk; central North Carolina especially adapted to its production.

North Carolina Experiment Farmer: Mosby did splendidly, very prolific, earlier than most varieties.

Texas Bee-Keepers' Association: The White Giant Normandy is a desirable variety for Texas, yields about 60 bushels per acre, and two weeks earlier than common.

Texas Honey Grove Grange: The Mosby is an excellent variety.

A report from Klickitat County, Wash. Ter., says: "Mosby's Improved Prolific Corn will prove of incalculable benefit to this section at the present time on account of the destruction of the native grasses by too close grazing."

OATS.

Burpee's Welcome are raised successfully from central Florida to southern Maine, but apparently increase in quantity and improve in quality as they reach more northern climates. In Maine 11 pounds of seed produces 84 pounds of grain.

Connecticut Experiment Station: Victoria "were perfect" and are especially valuable where oats are made into hay.

Maryland Statistical Correspondent: Hargett's White (seizure) proved a success, and are admirably adapted to central Maryland.

Pennsylvania State College: Hargett's White (seizure) Oats grew thrifty, with good broad leaf, and produced a good stand of straw and yield of grain.

WHEAT.

Kentucky Agricultural Experiment Station: Thus summarizes results of varieties tested: The Crimean, Egyptian, Indian Wheats, and Genoese were valueless, being unable to withstand the winters. The McGehee White was defective in having a weak straw. The Martin's Amber proved almost a failure. The Diehl Mediterranean proved to be an excellent variety and deserves attention by the farmers of the State. Of the three other varieties sent out by the United States Department of Agriculture, the German Emperor is a very promising variety. The Mediterranean Hybrid yielded more than any variety. It certainly is very promising and the best wheat we had this year. The Extra Early Oakley with us has proven itself a most excellent wheat. This wheat was so promising that some samples were sent out to try it on a larger scale. Dr. R. J. Spurr sends the following report:

"The Extra Early Oakley Wheat which I got from you has given me much satisfaction. I have noticed this wheat on the State College grounds for the past three years, and was impressed by its characteristics, and feel free to say that no greater boon could be conferred upon the farmers of this State than a general distribution of it throughout our State."

Connecticut Agricultural Experiment Station: Martin's Amber, Four Rowed Sheriff, Diehl's Mediterranean, McGehee's White, Raub's Black Prolific, German Emperor, and Fulcaster all do well in southern Connecticut.

Georgia Statistical Correspondent: The "Good" variety will be a success in West central Georgia.

Texas Pomona Grange: The Fulcaster is a little later than other wheats but grows taller and will no doubt be a success in northern Texas.

COTTON.

Arkansas Sand Creek Farmers' Club: Shine's Prolific is a vigorous grower, stands drought well, and holds its fruit better than most of the cotton tried.

Texas Agricultural and Mechanical College: The Jones' Improved and the S. B. Maxey were treated in exactly the same manner and after ginning, the lint and seed of each were weighed separately, and were next submitted to prominent and re-

liable cotton buyers, who were unanimous in their classification. The following table gives the results in full:

Variety.	Weight of seed cotton per acre.	Weight of seed per acre.	Weight of cotton per acre.	Classification.	Length of staple.
	Pounds.	*Pounds.*	*Pounds.*		
Jones (Improved)	557 1/7	378 4/7	178 4/7	Good middling	3/4 inch.
S. B. Maxey	557 1/7	375.	182 1/7	Middling	1/2 inch.

Both varieties were classed below the average of cotton raised in this (Brazos) country. The yield is about an average for our uplands, making about 1 bale to every 2¾ acres.

CLOVER.

California Agricultural College: Alfalfa is the chief reliance for hay and pasture in the irrigated districts of this State. Alsike grows well with moderate irrigation.

Pennsylvania State College: Alsike wintered well, grew very thick, and yielded a fair second crop.

Wisconsin Experiment Station: Seed of Alsike produced vigorous plants and will prove very valuable for pasture on moist lands.

TEOSINTE (*Euchlœna luxurians*).

Florida State Agricultural College: Teosinte is very difficult to cure in Florida by reason of its extreme succulence, but is very productive and a valuable plant for green soiling.

Missouri Agricultural College: Teosinte did well and promised to be a good forage plant; worthy of further trial on a larger scale.

Mississippi Agricultural and Mechanical College: We are much pleased with Teosinte, but wish to give it further trial before giving an opinion of its value.

Texas Bee-Keepers' Association: Teosinte is a wonderful forage plant; stands at the head of the list.

Texas Ledbetter Grange: Distributed Teosinte among its members, and some reported that 15 to 20 stalks grew from one kernel of seed and attained a height of 10 to 12 feet. Stock are very fond of it, and it is pronounced a valuable plant if it will produce seed.

D. Chalmers Ervin, Narrows, Brevard County, Fla., writes: "Out of a few small parcels of Teosinte sent me I got one-half dozen good specimen plants. These were planted September 1, and matured about January. These were planted on shell hummock land, and made as many as 10 or 12 branches to a single stalk. I am satisfied that it is a valuable forage plant and will thrive in this locality."

J. S. Erwin, Kirksville, northern Missouri, gives the following as his experience in the cultivation of Teosinte: "In the spring of 1884 I procured a few seeds which I planted in one row, hills 4 feet apart, planted in the middle of May, two seed to the hill, cultivated same as corn. October 15 I cut some of the best hills and weighed them; the heaviest weighed 62 pounds. After being dried for two months in the shed they weighed 22 pounds. The following year I procured more seed and planted about an acre, hills 4 by 4 apart, same hills weighed 44 pounds. Counting the entire crop at this rate the result would be 116,600 pounds green fodder, or 41,200 pounds of cured.

"I do not think that this is the maximum, as I claim no particular skill, and the crop had scarcely a fair chance, as the weeds and grass were allowed to almost choke it at first. The ground was heavily manured, but would hardly have produced 100 bushels of corn to the acre under the most favorable circumstances. The growth was about five months, the height about 9 feet. It is relished by all kinds of stock, from horses to hogs.

"In the spring of 1886 one of my tenants planted less than one-half an acre on ground which had been in cultivation for fifteen years without manure, and would not have produced more than 40 bushels of corn to the acre. The result was four large loads of dry fodder, probably equivalent to 5 or 6 tons per acre, although the season was an excessively dry one."

A sample of Teosinte was examined by the Chemist of the Department with the following results:

	Original sub.	Dry sub.	Air dried.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	88.57	....	12
Ash	1.57	13.65	12.01
Oil	.41	3.56	3.13
Nitrogen free extract	5.39	46.87	41.25
Crude fiber	2.41	21.02	18.5
Albuminoids	1.71	14.9	13.11
	100	100	100
Nitrogen	.274	2.38	2.1

For comparison, analyses have been copied of clover and timothy hay:

	Clover.	Timothy.
	Per cent.	*Per cent.*
Moisture	15.02	12.59
Ash	5.15	4.23
Oil	1.98	2.03
Nitrogen free	40.12	44.88
Crude fiber	26.35	29.93
Albuminoids	11.38	6.36
	100	100

Thus proving that the Teosinte is considerably richer in albuminoids than other fodders, and is on that account valuable to combine with feeding materials poorer in nitrogen.

Kaffir Corn.

Arkansas Farmers' Club: It is almost impossible to say too much in its favor as a grain and forage plant.

Florida Agricultural College: Kaffir Corn has proved a valuable acquisition to our forage plants whether green or dry. The grain is also a consideration, as so much more can be grown per acre than from Indian Corn.

Mississippi Agricultural College: Kaffir succeeds well in central Mississippi.

North Carolina Experiment Farmer: Kaffir Corn is a splendid forage plant and yields an abundant crop of grain.

Texas Bee-Keepers' Association: Kaffir Corn is a success and is one of the best of forage plants. The seed is highly relished by poultry.

REPORTS ON MISCELLANEOUS SEEDS AND FIELD CROPS.

Russian Forage Plants.

Dakota Territory, Grant County: Vicia villosa does well, grows luxuriantly, lives over the winter, and comes out in spring in fine order.

Idaho, Ada County: Jaeger Beans germinated well and grew luxuriantly. *Vicia villosa* germinated and grew well and was a success. *Blue Lupins* germinated and grew finely, but failed on account of too much moisture.

New Jersey, Salem County: Vicia villosa grew luxuriantly. If sown not too thickly on good rich land it may be profitable. *Spergulum Maxima* grows very rank when sown upon good ground and promises to be a good forage plant and feed for sheep.

North Carolina, Moor County: Blue Lupins is a good forage plant and yields about 50 per cent., but not as good as the Southern Lupins, which grows in North Carolina and is highly prized as a fertilizer when turned under while green.

Abyssinian Grass (*Eragrostis Abyssinica*).

Texas Agricultural Society: Had much to contend with in wind and rain, but some of it being cured for hay it proved to be very fine. Pronounced the finest grass seen in this region. Cattle are very fond of it.

Texas Horticultural Association: Perennial rye-grass and Texas Blue excel all others in central Texas for winter pasture. Whoever invests in these grasses will make no mistake.

Millet (*Oryzopsis cuspidata*).

Kansas Agricultural State College: Indian millet does remarkably well in northeastern Texas.

Potato.

Michigan Agricultural College: The Polaris variety is smooth, good shape, fair size, ripens earlier than most of the early varieties.

New York Agricultural Experiment Station: Thirty-three single eye cuttings of the Polaris yielded 17 merchantable tubers weighing 51 pounds 3 ounces, and 70 unmerchantable tubers weighing 51 pounds 9 ounces.

A correspondent in the District of Columbia thus writes: "I planted the Polaris Potato in alternate rows with the Early Rose and Beauty of Hebron, treating them all alike as to day of planting, fertilizing, and cultivation. The Polaris came up first, blossomed first, and were ready for the table six days before the Early Rose and eight days before the Beauty of Hebron. We considered the Polaris the best eating potato of the three, white, mealy, and free from core; in fact, the best early variety I have ever raised, and I have tried all the new ones that have been put upon the market during the past dozen years."

Sorghum.

Sorghum is well adapted to the soil and climate of Texas, both as a forage plant and as a sugar-cane, and if the planter had suitable machinery for sugar making it would no doubt become exceedingly valuable.

Texas Horticultural Society: One acre "Orange" Cane made 96 gallons fine sirup.

Texas Bee-keepers' Association: Sorghum is a desirable forage plant, producing two crops of 3 or 4 tons per acre.

Texas Agricultural Society: The Early Orange Cane has proved entirely satisfactory, and will probably take the lead in the southeastern part of Texas.

Sunflower (*Giant Russian*).

From queries submitted by the United States Department of Agriculture with regard to the qualities of the Giant Russian Sunflower, we summarize the following: It will yield when planted on bottom-lands along the Potomac 60 bushels per acre. In feeding value it was found superior to corn for the following reasons: It contains more carbon as a heat-giver when fed to hogs; it produces a peculiar laxative effect on horses and cows, giving them a fine, glossy coat similar to that of the Arab horse. To horses and cows it was fed at the rate of 1 pint per day. When ground and mixed in the proportion of one-third sunflower to two-thirds corn or wheat middlings it is superior to any fattening or condition corn or condiment. As fuel it is of little value, but as fiber it is valuable and we have a sample of paper of unusual strength made from its fiber by the natives of Tashkand. No oil has been expresse for want of machinery, but by chemical analysis it was found to contain 11 per cent. of the total weight of the grain. The oil is palatable as a condiment and far superior to Olive oil for domestic purposes. While it may have a value in a sanitary point, it is most likely an indirect one, not by absorbing air [miasm] but by absorbing an immense quantity of water and throwing off an excess of ozone, rendering by this means an excess of miasm innoxious.

Vegetable Seeds.

Illinois Crop Reporter: Burbridge's Eclipse Peas, Red Wetherfield Onion, and Eclipse Beet do remarkably well.

Kansas Farmers' Institute: Golden Refugee Bean, Sutton's Gem Lettuce, Laxton's Earliest of All Peas, Golden Sugar Corn seem to be well adapted to central Kansas.

Missouri Experiment Farmer: The Cranberry, Early Refugee, and Early Six Weeks Beans are a success and are very productive. Montreal Market Musk-melon is A No. 1. The Paragon and Livingston Beauty Tomato are tip-top growers and bearers.

New Hampshire Agricultural College: The Beet, Carrot, Cabbage, Cauliflower, Kale, Onion, Spinach are all grown successfully in central New Hampshire.

South Carolina Agricultural Society: The All Seasons Cabbage and All the Year Round Lettuce proved very fine.

South Carolina Statistical Reporter: The Peerless, Kolb's Gem, and Iron-Clad Water-melons are very large. Norfolk, White Globe, French Globe Turnips are all desirable. The Golden Rose is a delicious turnip.

Tennessee Agricultural Society: The Early Six Weeks and Golden Rose Turnips are both of superior quality.

Texas Agricultural College: The Louisiana Okra is the best ever grown in central Texas. The Danver Carrot, Early Mayflower Tomato, and Acme are very superior. Long Green Cucumber and Boston pickles promise well.

Texas State Horticultural Association: The Milan Strap Leaf and Purple Top Strap Leaf Turnips yielded abundant returns of magnificant turnips; Prolific Pea was a grand success.

Texas Agricultural Society: The Beaumont's Wonder Water-melons were very fine, some weighing over 50 pounds.

Virginia Agriculture Society: Kolb's Gem Water-melon was a success. "All seeds from the United States Department were carefully tested, and in no one instance have they failed to germinate."

CONDENSED REPORTS FROM CORRESPONDENTS.

ALABAMA.

Corn.—Mosby and White Giant Normandy have been cultivated with great success in the southern part of the State, and are excellent varieties for general cultivation for both field and table.

Oats.—Burpees' Welcome, planted in the northwestern portion of the State, had fine, large heads, although the season was very unfavorable.

Wheat.—The Fulcaster, Early Oakley, and McGehee succeeded well in all parts of the State. The Fulcaster proved the best.

Cotton.—Shine's Prolific proved very vigorous, withstands drought well, and holds its fruit better than other varieties. The Peerless, planted in the southern part of the State, germinated 95 per cent. of its seed, is very productive, but has a tendency to dry up.

Teosinte.—Grows luxuriantly and can be cut two or three times during the summer. Stock are very fond of it.

Kaffir Corn.—Is vigorous, and resists the ordinary vicissitudes of weather.

Tobacco.—General Grant is a fine variety that ripens early and yields well. Havana yields largely, is easily cured, and has a fine flavor.

Vegetables.—Of the many varieties sent out by the Department, the Excelsior Evergreen Corn, Trophy Tomato, Laxton's Marvel Pea, and Extra Early Bassano Beet are special favorites, while all seem adapted for general cultivation throughout the State.

ARKANSAS.

Corn.—White Giant Normandy in the northwest, and the Mosby in the central part of the State, did finely, and both seem well suited to the soil and climate.

Cotton.—Jones' Improved, planted in the northeastern portion of the State, will make one-third more per acre than any other cotton raised in Arkansas. Shine's Early Prolific is also raised in the southeast with satisfaction and profit.

Clover.—Alfalfa is very productive. Two packages received from the Department in 1885, after two years' growth, now covers half an acre.

Teosinte.—Has made a fine growth in this State, and it is thought will excel Millet or Hungarian.

Kaffir Corn.—Does well in the southwestern part of the State; grows about 6 feet in height, is very heavy headed, and produces tremendous amount of foliage. "It is impossible to say too much in its favor as a grain and forage plant."

Tobacco.—Orinoco, Havana, and White Burley are all grown in the northwest part of the State, but Orinoco is best adapted to the locality.

Vegetables.—Mohawk and Early Red Valentine Beans, Pine-apple and Bassano Beet, Peerless Cucumber, Commodore Nutt Lettuce, and Livingston Tomato are among the many varieties of vegetables that do well in this State.

CALIFORNIA.

Oats.—From 1 quart of seed of the Hargett's White (seizure) sent from the Department $64\frac{1}{2}$ pounds of grain was produced.

Clover.—Alfalfa and Alsike both grow luxuriantly in central California with moderate irrigation.

Tobacco.—The Havana raised from the seed sent from the Department to southwestern California was awarded the first premium at the San Diego County Fair and pronounced by competent judges the best they had ever grown in this locality.

Vegetables.—The seeds of all the varieties sent from the Department were a success. Vegetables grow finely throughout the State when irrigation is practical, and with wonderful results.

COLORADO.

Corn.—Pride of the North is very valuable for the southwestern part of the State; matured earlier than eight other varieties planted at the same time. The yield was very large for this latitude. The Yellow Mammoth King also produced a fine crop.

Oats.—Burpee's Welcome yielded well and is adapted to the southwest.

Wheat.—The German Emperor grows well in the central part of the State. The straw is stiff, had some rust, and from seed received harvested 4 bushels, 60 pounds to the bushel. The grain was large and fine.

Vegetables.—Thrive here, especially melons and other vines.

DAKOTA.

Corn.—Pride of the North has proved of permanent value in southeastern Dakota.

Oats.—Burpee's Welcome, sown in central Dakota, yields well and is of superior quality, producing magnificent heads. The Hargett's White in the same locality were ten days earlier than the Victoria, but not as good quality and a much lighter yield. The Board of Trade and Australian varieties have proved to be of permanent value in the southeastern part of the State.

Wheat.—Egyptian Fife is taking the lead in the southern part of the State.

Clover.—Alfalfa has been very successful in the northwest and is likely to become the future forage plant of Dakota. The Alsike did remarkably well in the western central portion of the State. The Mammoth Red Clover made a fair growth and seeded well, but does not appear to be adapted to Dakota's needs. Perennial grasses are what is required for pasture.

Tobacco.—Szegedina, planted in the southeastern part of the State, ripens early and the quality is good, but on account of winds must be planted in well-protected places.

Sunflower.—The Russian is cultivated throughout the State, and yields at the rate of 75 bushels to the acre. It ranks with corn as feed for chickens, but has to be fed with other grain. It is valuable as kindling, and is worth \$5 per acre as light wood.

Vegetables.—There is no limit to the supply of vegetables in favorable seasons. While all grow well, Melons are exceedingly fine, some weighing from 20 to 25 pounds.

FLORIDA.

Corn.—The White Giant Normandy is grown with success in the northwestern portion of the State. The Mosby in the same locality has proved very prolific; it has a small cob, large ear and stalk.

Oats.—Burpee's Welcome is a very rapid grower. The heads are very full, having from 110 to 120 kernels on a stalk. This variety is free from rust and is undoubtedly a good one for central Florida.

Teosinte.—This plant is becoming very popular as a forage plant in all parts of the State. It yields an enormous amount of fodder of extra quality. It can be

cut three times in a season, and yields not less than 3 tons per acre each time. It is fully adapted to this soil and climate; but for the difficulty in obtaining seed its use would be universal.

Kaffir Corn.—Seems oblivious to heat and drought and is liked better than any of the (grain and fodder) Sorghums. More can be grown per acre than from Indian Corn, and it will no doubt become an important crop in all parts of the State.

Sunflower.—Cultivated in the central districts, it grows to a large size, some of the seed heads measuring 34 inches in circumference. The yield of seed was light and will not pay as well as a corn crop.

Tobacco.—Of three varieties planted, Havana, Deli Sumatra, and Sagua la Grande, in the northwest part of the State the Sumatra was somewhat the best, although all do well.

Vegetables.—The Refugee Bean, the Pine Apple, and the Eclipse Beets, the Drumhead Cabbage, Georgia Collards, and First and Best Pea are popular sorts. All the varieties distributed by the Department succeed admirably when planted early enough.

GEORGIA.

Corn.—The Mosby has been a satisfactory variety, planted in all parts of the State. Further trial is necessary before it can be pronounced the best. It withstands drought well and will yield 50 bushels to the acre. The Kaffir has given the same results in the same localities.

Oats.—The Hargett's White (seizure) was planted in the southern part of the State and from 1 quart, one-half bushel, 16½ pounds to the bushel, were harvested.

Wheat.—The German Emperor, sown in the central and northern portions of Georgia, is reported as producing four times as much as other varieties sown. Fulcaster has given satisfaction. The grains were large, plump, and of fine quality.

Clover.—Alsike in the southwest and Alfalfa in the northern portions of the State did well this year.

Cotton.—The S. B. Maxey grown in the southwestern part of the State is a good variety, is very prolific, and has fine lint. Every 100 pounds of seed makes 36 to 38 pounds of lint. Shine's Early Prolific in the southeast is a wonderful bearer. Taylor, planted in the central, is also good and very prolific.

Teosinte.—Has done well in this State. It yields 1½ tons per acre. All stock eat it greedily. It is reported as yielding more to the acre than Indian Corn.

Kaffir Corn.—Has succeeded well in the central districts. It withstands dry weather, and will perfect its grain when maize will fail. It will make two crops in the season. It will undoubtedly be largely planted next year. "It will fully repay any farmer who plants it."

Tobacco.—The Connecticut Seed Leaf and General Grant varieties both did well; the latter had some leaves 2 feet 10 inches in length and 18 inches in width.

Vegetables.—The Mexican Water-melon vines grew luxuriantly, and the yield was good. The fruit was small, but unusually delicate. It promises great results under favorable circumstances. The Cranberry Pole and Extra Early Six Weeks Bean, the Pine Apple Beet, the Southern Drumhead and Late Flat Dutch Cabbage, Early Minnesota Sweet Corn, and the White Spine Cucumber were grown successfully.

ILLINOIS.

Corn.—The Pride of the North raised in the central part of the State yielded well. The Corn was sound and the ears were well filled.

Oats.—The Burpee's Welcome were extra fine, raised in the west central part of Illinois.

Wheat.—The German Emperor, raised in the central portion of the State, was very satisfactory in yield and quality. One-fourth of an acre sown yielded 2½ bushels, weighing 59½ pounds to the bushel. The straw was stiff and not affected by the rust.

Vegetables.—The Early Blood Turnip and Long Dark Blood Beets, the Etampes and Berkshire Beauty Cabbage, the Excelsior Evergreen Corn, the White Spine Cucumber, the Early Curled Simpson and Early Hanson Lettuce, the Montreal Market and the Nutmeg Melon, Kolb's Gem and Beaumont's Wonder Water-melon, the Giant Globe and Danvers Onion, the Golden Bush Squash, and the Snowball Turnip are all reported as having been very productive and of excellent quality, notwithstanding the severe drought.

INDIANA.

Corn.—The Pride of the North was planted May 6. It matured about August 8 and took the first premium at the Marion County Agricultural Fair.

Oats.—The yield of the Burpee's Welcome has been immense. It matures early and has full heads, plump stalk, and took the first premium at the Marion County Agricultural Fair.

Wheat.—The Fulcaster has good bright straw and is free from rust. The grain is large and fine. A good variety for central Indiana. Raub's Black Prolific in the same locality made a splendid crop when other wheat did not pay for the cutting. Fulcaster also did well here. The Red Mediterranean produced well in the southern portion of the State.

Clover.—Alsike has proved a very valuable honey plant in the central part of the State. It does well when planted in drills and cultivated until it gets a start.

Grass.—The Orchard Grass has yielded the largest returns of any grass seed planted for years.

Potatoes.—Notwithstanding an exceedingly dry season the Polaris variety yielded well in the central portion of the State. It is deemed worthy of further trial.

Sorghum.—Has been cultivated in the northern section with success. Early Amber Cane made a good yield of very superior sirup.

Vegetables.—The Long Dark Blood and Improved Half Round Beets, the Surehead and Winningstadt Cabbage, the Excelsior Evergreen and Early Minnesota Corn, the Long Green Turkey Cucumber, the Early Hanson and Boston Curled Lettuce, the Cuban Queen Water-melon, the Red Wetherfield Onion, the Boston Marrow and Crook Neck Squash, the Purple Top Strap Leaf Turnip are worthy of general cultivation.

IOWA.

Corn.—The Mammoth King and Yellow Dent Corn have been raised with favorable results.

Oats.—In the northeastern part of the State the Burpee's Welcome have been cultivated successfully.

Wheat.—Grows well in the northeastern part of the State. Michigan Amber, Fultz, and Red Missouri yield from 12 to 15 bushels per acre.

Pyrethrum roseum.—This plant does well in the central district of Iowa. It resists the drought and is a valuable plant.

Vegetables.—The White Imperial Sugar Beet made an enormous yield. The Extra Early Bassano is a fine sort. Surehead Cabbage planted in the central part of the State grew very large. Some heads weighed 24 pounds and were of fine flavor. Excelsior Evergreen and other Sugar corns have given fine results. White Spine Cucumber is the standard for this climate. Musk-melons do well, and Kolb's Gem Water-melon are of delicious flavor and gave average weight of 23½ pounds.

KANSAS.

Oats.—The Early Welcome succeeded well in the southwestern part of the State.

Wheat.—The Fulcaster, sown in the northwest portion of Kansas, produced 50 pounds from 1 quart of seed, although much affected by drought and Chinch-bugs. The straw was very stiff, did not rust, and the grain was good. The German Emperor tillered well, producing as high as 30 heads from one grain.

KENTUCKY.

Wheat.—The McGehee's White produced well in the northwestern part of the State. From 1½ pounds seed sown 88 pounds of nice wheat was thrashed, and some was lost by the handling. The Fulcaster and Diehl Mediterranean straw was of medium size and free from rust. Although a good yield was secured the Fultz is preferred in the central portion of the State. The German Emperor also ripened well and was not affected by the rust.

Vegetables.—The Beans grew luxuriantly and are of long continuance. The Peerless Cucumber was crisp and tender. The Victoria Lettuce was very superior. The Pride of Georgia Melon small, but very sweet, and ripens out close to the rind. The Netted Gem Musk-melon was small, but sweet and delicious.

LOUISIANA.

Corn.—The Mosby, grown in central Louisiana, is very prolific and very heavy; a flour barrel, in shucks, often shells out 72 pounds. It has proved all that has been claimed for it.

Ramie.—There is little doubt this will prove a success in the Mississippi lands. It has grown to the height of 8 feet. With proper machinery it is believed it could be made a more profitable crop than cotton.

Cotton.—The Jower's Prolific bids fair to take the lead of all cotton raised in central Louisiana. The Taylor and the S. B. Maxey are both good varieties.

Teosinte.—Is among the best green feeds yet introduced into the South. It is excellent for stock, and can be cut several times during the season. Although it produces luxuriant foliage, a fatal objection is the difficulty in obtaining seed. It is thought that it will seed in the central and southern parts of the State if planted by March 1.

Kaffir Corn.—Is cheaply raised. Is excellent for stock or poultry. It will yield more than any other plant in grain and fodder.

Vegetables.—"The seeds received from the Department proved to be the earliest and best adapted to this section, and much earlier than vegetables raised from seed grown here." "They are an acquisition that is appreciated." "The Beans, Beets, Cabbages, Peas, Tomatoes, Turnips, and Water-melons gave entire satisfaction. They were early and bore abundantly."

MAINE.

Oats.—In central Maine, among the small grains, oats produce the largest average yield. The Burpee's Welcome produced 84 pounds of good grain from 1 pound of seed sown.

Vegetables.—Planted by the middle of May are generally successful. The Refugee and Extra Early Mohawk Beans are hardy and productive. The Early Eclipse Beet can not have too much said in its favor. The Early Genesee Corn is the best ever raised in southern Maine. The Extra Early Paris Cabbage produced 50 heads of the best quality. The Alaska and Edinburgh Beauty Peas, Long Sugar Parsnip, Snowball, and Purple Top Turnip all do well in southern and central Maine.

MARYLAND.

Oats.—The Hargett's White (seizure) is raised very successfully. It yields well, is of excellent quality, and is no doubt well adapted for general cultivation.

Wheat.—Fulcaster and Raub's Black Prolific were both raised. The Fulcaster yielded good grain, but it was not sown on soil well adapted to it. Raub's Black Prolific had strong, heavy straw, free from rust, and was well filled with grain of fine quality.

Vegetables.—The Early Rachel and Refugee Beans are valuable varieties. The beets have exceeded the most sanguine expectations. The Long Green Cucumber is a fine variety. The onions grow very large, many of them weighing 1 pound. The First and Best and Edinburgh Beauty Peas were of extra quality.

MICHIGAN.

Barley.—The Melon Barley imported from Russia and distributed by this Department in the spring of 1886, has proved to be one of the best varieties ever introduced into the barley-growing districts of the State.

Oats.—Burpee's Welcome is an excellent variety for central Michigan. One quart of seed produced 70 pounds of the very best grain. The heads were fully one foot in length and the straw tall and strong.

Wheat.—In Southern Michigan the German Emperor has been raised with great success, and the quality of the grain is A No. 1. Fulcaster yields large plump grain, and is an early, hardy winter wheat. The German Emperor resembles in some respects the Diehl Mediterranean. It stood when other wheat was all down, and was entirely free from rust.

Potato.—The Polaris planted in central and southern Michigan yielded well, and the tubers were smooth and of good shape, fair size, and ripened earlier than most other varieties.

Tobacco.—General Grant was two or three weeks earlier than other varieties and of good quality.

Vegetables.—The Edinburgh Beauty Pea is especially fine and true to name. The Dutch Case Knife Beans can not be excelled. The Golden Sugar Corn was very fine. The Long Green Cucumber is a desirable variety. The Excelsior Drumhead Cabbage, Carrot, Melons, Radish, Turnip, Squash, all produced well and were of good quality.

MINNESOTA.

Wheat.—The German Emperor raised in the southern part of the State tillered abundantly. Came through the winter in very good condition. The heads were very large, ripened evenly and yielded good No. 1 wheat.

Vegetables.—The Refugee Beans, the Early Blood Turnip Beet, the Excelsior Evergreen Corn, the Winningstadt Cabbage, the Water-melon, Onion, and Peas are desirable varieties throughout the State.

MISSISSIPPI.

Corn.—The White Giant Normandy in the central part of the State produced a good crop notwithstanding the very unfavorable weather. The Mosby made a wonderful yield for central Mississippi. On good land it is a success.

Wheat.—Red Mediterranean sown in northern Mississippi had no signs of rust, which is a great object in this climate. From 1 pound of Fulcaster seed 34 pounds were harvested of clean nice wheat. It seems to be rust-proof and a good variety for this climate.

Cotton.—The S. B. Maxey's, the Jones' Improved, and Cherry's Long Staple are raised in all parts of the State with success. The Maxey produced at the rate of 1,800 pounds per acre and withstands drought better than most other cotton. The seeds are small, the bolls large, and the lint fine. The Jones' Improved yielded at the rate of 1,200 pounds per acre.

Teosinte.—Seems to be well adapted to this climate. This State needs some good forage plants, and if this fulfills its present promise it will be a boon. It is worthy of a further trial.

Kaffir Corn.—Will produce one-fourth more feed to the acre than ordinary corn. Stock relish it, and it withstands drought exceedingly well.

Sorghum.—The Amber Cane is well adapted to the central part of the State, and yields from 80 to 100 gallons of fine sirup to the acre. It is the earliest cane raised.

Vegetables.—The Department seeds were a grand success. The Edinburgh Beauty pea is a very desirable variety. The Beans, Radish, Lettuce, Tomato, and other varieties were very satisfactory. There is a growing demand for Department seeds throughout the State.

MISSOURI.

Corn.—The White Giant Normandy is the favorite stock corn in this State. It is very early, and for this reason very valuable in dry seasons. It yields from 40 to 60 bushels per acre. The Pride of the North is also a desirable variety.

Oats.—The Burpee's Welcome did well in the central part of the State. The grain was plump and full and the straw heavy. The Hargett's White (seizure) has proved a success, and is admirably adapted to central Missouri.

Wheat.—The Fulcaster has been raised in central Missouri with success. In southern Missouri the German Emperor has given satisfaction. The straw was strong and stiff, did not rust, and the quality of grain was good. In Livingston County the Diehl Mediterranean and the Martin's Amber are considered valuable varieties.

Clover.—The Alsike in the central part of the State has given good results. The Alfalfa wintered well, gave one good crop, but when the second began to grow it was shortened by the drought. It has been comparatively unknown in this section, but will undoubtedly prove a valuable acquisition.

Teosinte.—Has been tried in Missouri. It needs further experiment to decide its value. From present indications it is likely to prove of much value for forage purposes, notwithstanding it fails to produce seed north of the 31st degree of latitude. A single seed produced 50 stalks of excellent forage.

Kaffir Corn.—Has succeeded in the western part of the State. It withstands drought better than any other fodder plant known in the North.

Potato.—The Polaris yielded well in the central portion of the State. It is of fine quality, and was not affected with rot.

Sorghum.—The Early Amber Cane has produced well, yielding in a good season fully 140 gallons of excellent sirup to the acre.

Sunflower.—The yield of the Russian variety was very large. It is used almost exclusively as feed for poultry.

Tobacco.—The Connecticut Seed Leaf made a fine growth in Vernon County. It is of fine texture, fine flavor, easy to cure, and yellows early. The Orinoco, a well-known variety of yellow tobacco, also produced a fine crop.

NEBRASKA.

Corn.—The Pride of the North ripened in less than 90 days after planting, notwithstanding several weeks of severe drought. The yield was about 40 bushels to the acre. It is the corn needed in Nebraska.

Oats.—The reports indicate that the Burpee's Welcome is an excellent variety throughout the State.

NEW YORK.

Corn.—The Pride of the North in the southwestern part of the State is spoken of in the highest terms both as to quality of grain and as the earliest to ripen of any of the Dent varieties. The Mosby, although a Southern variety, has done well this year in central New York. It will be raised more extensively next year.

Clover.—The Alsike is grown successfully in central New York and seems to be especially adapted to heavy soils.

Teosinte.—Has done very well in Schenectady County.

Kaffir Corn.—Has made a very satisfactory crop. It will doubtless be a success in the same locality.

Potato.—The Polaris has been raised with very satisfactory results, and gives promise of becoming a popular variety.

NORTH CAROLINA.

Corn.—The Mosby is a beautiful variety. It yields well and is well adapted for general cultivation. A correspondent writes from central North Carolina: "I have tried four varieties and find the Mosby the best of all."

Wheat.—The Fulcaster is an excellent variety for the central portion of the State. It is free from rust and the quality of the grain is good. Raub's Black Prolific was planted in the central part of the State. The straw was stiff; it had some rust, but it did not seem to injure it, for the grain was large and plump. The Genoese and Martin's Amber both were satisfactory in quality and in yield.

Cotton.—The Jones' Improved Prolific has been found to be something extra in central North Carolina, yielding one-fourth more per acre than the other varieties. It is a choice variety for sandy lands, withstands drought better, and holds its form where other kinds fail. Cherry's Long Staple has linted and fruited well. Shine's Early Prolific and the S. B. Maxey have given satisfaction.

Teosinte.—Does well and yields abundantly, and will become a valuable forage plant if it will mature seed.

Clover.—The White Clover is excellent for pasturage purposes and is well adapted for general cultivation in this State.

OHIO.

Corn.—The Pride of the North is a very early corn, and promises to be extensively planted in the central and northern part of the State. The Yellow Mammoth King is a vigorous grower and resists drought well.

Oats.—Burpee's Welcome is a valuable acquisition.

Wheat.—The German Emperor is a very popular variety, and is well adapted to central Ohio. The yield was unprecedentedly large under very unfavorable circumstances. The McGehee took the first premium at the Clark County fair, and attracted considerable attention. Its weight was tested, and was found to be when ready for seed 63 pounds. Mr. Barnett, of Barnett's Mills, found it the best milling wheat he had seen. What is more remarkable, "it increases in weight every year."

The Martin's Amber and Extra Early Oakley were also superior varieties for the same locality.

Sorghum.—Has been cultivated with marked success, both Amber and Orange Cane yielding well, producing an excellent quality of sirup.

OREGON.

Tobacco.—The Connecticut Seed Leaf, the Orinoco, and the White Burley are spoken of in the highest terms for general cultivation in central Oregon.

PENNSYLVANIA.

Oats.—The Hargett's White is of vigorous growth, the straw is stiff, the quality of grain good, and is the variety for central Pennsylvania.

Clover.—The Alsike wintered well. It grew thickly and yielded a fair second crop.

Pyrethrum Roseum.—Succeeds well in the central portion of the State. Grows slowly at first, but when once started it is very satisfactory.

Vegetables.—The Red Cranberry Pole and the Early Mohawk Beans were excellent. The Excelsior Sugar and Dark Blood Beet, the Excelsior Flat Dutch Cabbage, the Pride of Florida and the Cuban Queen Watermelon, the Emerald Gem and Gray Seeded Sugar Peas were very thrifty growers, and yielded abundantly.

SOUTH CAROLINA.

Rye.—The Multiplying Rye yielded a good crop, notwithstanding a very severe winter.

Wheat.—The Martin's Amber yielded a good quantity of very nice wheat.

Cotton.—The Jones's Improved has done much better than the Maxey in the central part of the State.

Teosinte.—Has proved to be a good forage plant and is likely to be of much value.

Kaffir Corn.—Was experimented with only to a limited extent, but was very satisfactory. The experiment was not perhaps sufficiently thorough to give an accurate test as to quantity.

Vegetables.—Vegetable seed received from the Department has given universal satisfaction in yield, in earliness, and in quality. Most of the varieties are well suited to all parts of the State.

TENNESSEE.

Corn.—The Mosby is well adapted for general cultivation throughout the State.

Oats.—The Hargett's White has proved to be a very satisfactory variety.

Wheat.—The Fulcaster yielded a good quantity of large clean grain of good quality. The McGehee gave the best results of any variety planted in central Tennessee.

Cotton.—Shine's Early Prolific withstands drought better than any cotton raised in the central part of the State. One quart of seed yielded 53 pounds of seed, 27 pounds of lint, and has a fine staple.

Sunflower.—The Russian was planted the 10th of May, in Houston County, northern Tennessee, on upland soil, a light clay. It yielded at the rate of nearly 100 bushels to the acre.

Vegetables.—In central Tennessee the Mohawk Bean proved to be very early, large, and tender. The Pine-Apple Beet, the Berkshire Beauty Cabbage, the Alaska and the Edinburgh Beauty Peas, in fact all vegetables produced from seeds procured from the Department are 50 per cent. better than those grown from seed raised here.

TEXAS.

Corn.—The White Giant Normandy was planted two weeks later than other varieties, but it came up and outgrew them by two weeks. It yielded one-half more than any other variety, in some cases yielding at the rate of 45 bushels to the acre, while other corn with same care made nothing. The Mammoth King yielded 20 bushels to the acre, while an old variety, planted two weeks earlier, yielded from 10 to 15 bushels. The Mosby is very prolific. It would no doubt yield on bottom lands 50 bushels to the acre. It is an excellent variety.

Wheat.—The Fulcaster is somewhat later than other varieties in ripening, but the grain is well developed, plump, and superior in quality to other wheat. The straw was strong and stiff. It is undoubtedly a valuable variety for central Texas. The Genoese was also quite satisfactory.

Cotton.—Shine's Early Prolific seems well adapted to central Texas, but owing to excessive drought this year has hardly had a fair test. It yielded 400 pounds seed cotton per acre, 14 pounds of fine lint, the staple being of medium length. Cherry's Long Staple also did well, notwithstanding the drought.

Clover.—The Alfalfa is one of the most productive of the clovers grown in central Texas.

Teosinte.—Is pronounced a very valuable forage plant in the central part of the State. Fifteen to twenty-five stalks grew from one kernel of seed to a height of 10 to 12 feet. Stock are very fond of it, but it has as yet produced no seed.

Kaffir Corn.—Has been eminently successful; resists drought better than corn or sorghum. It is all that is claimed for it. Cattle like the thick stalks, chickens the seed. It will prove a bonanza for Texas.

Grasses.—The Perennial Rye and Texas Blue Grass excel all others for pasturage purposes. The *Abyssinica eragrostis* grows well in the central part of the State.

Sorghum.—The Early Orange Cane will take the lead in the southeastern part of Texas for earliness, quantity, and quality. The Amber has also been planted with good results.

Sunflower.—The Russian variety, owing to the drought, yielded but 20 bushels to the acre. Its feeding value as compared with corn was about 80 per cent.

Tobacco.—The General Grant and the One Sucker varieties both grow well in northeast Texas.

VIRGINIA.

Corn.—The Pride of the North grows well in central Virginia. The cob is well covered; it is early, and there is less short corn and faulty grain than in most of the common varieties. The Mosby proved valuable in the same locality. It is a very fine field corn.

Oats.—Hargett's White is a success in the central portions of the State, although the crop for this year was not a fair test.

Wheat.—The German Emperor gave a good yield of beautiful wheat. The straw is stiff, does not rust, and will prove a success in central Virginia. The Diehl Mediterranean was not affected by rust; quality of grain was good. Raub's Black Prolific, subject to rust, but the grain was first class.

Cotton.—Only a small quantity of Shine's Prolific was planted for a test. It did very well and will no doubt succeed in the southeast portion of the State.

Clover.—The Alsike was very productive. Wherever a seed struck the ground it seemed to grow and flourish.

Teosinte.—Grew in some cases 10 feet in height and produced 28 stalks from one seed. A correspondent writes: "If used for ensilage it would be far cheaper than maize, as 1 acre would produce four times as much."

Kaffir Corn.—Has succeeded well; fowls eat the seed. The seed if ground into flour has been found to be equal if not superior to buckwheat for family use.

Tobacco.—T. Plunkett, Blacksburgh, Montgomery County, Va., writes: "We experimented with Caboni tobacco and found it one of the earliest varieties tried among many. It was of remarkably strong and vigorous growth; the stalks were strong but small. The leaves were small ribbed, very elastic, of fine texture, and when properly cured in the sun of a light-brown color, and of the most delicious flavor. From our experience we are satisfied that one-third more of this tobacco can be grown on the same ground with the same treatment than any other variety."

WEST VIRGINIA.

Corn.—The White Giant Normandy was of good quality. The ears were well filled, and from 25 to 35 bushels to the acre were produced.

Oats.—The Burpee's Welcome did splendidly; the grain was first class, and admired by every one."

Wheat.—The German Emperor grows much like the Fultz. The straw of the Diehl Mediterranean was stiff and free from rust. It yielded a good quality of grain.

WISCONSIN.

Barley.—The Melon has been raised with very good results. It will be carefully tested next year.

Corn.—The Pride of the North, planted in the northern part of the State, produced a splendid crop, yielding fully 60 bushels to the acre. The Mammoth King germinated every kernel. It grew well and continued to grow through drought and hot weather. An observation of fifty years, says this correspondent, has never more clearly shown the importance of selecting seeds of the best quality.

Oats.—The White Russian variety sent from the Department four years ago is now almost exclusively raised in central Wisconsin. It is yielding a better quality than any other kind yet tried.

In conclusion, I herewith append the following tabulated statement, showing the quantity and kind of seed issued from the seed Division of the Agricultural Department, under the general appropriation act of Congress, from July 1, 1886, to June 30, 1887:

Quantity and kind of seeds issued from the Seed Division of the Agricultural Department, under the general appropriation act of Congress, from July, 1886, *to June* 30, 1887.

Description of seeds.	Varieties.	Senators, Representatives, and Delegates in Congress.	Statistical correspondents.	State correspondents.	Miscellaneous applicants.	Experiment stations and agricultural colleges.	Agricultural societies.	Grand total.
		Packages.	*Packages.*	*Packages.*	*Packages.*	*Packages.*	*Packages.*	*Packages.*
Vegetable	197	2,955,933	161,560	38,910	436,704	10,776	5,865	3,609,748
Flowers	140	262,094	45,823	2,518	83,594	108	....	394,137
Herbs	1	....	....	....	21	....	....	21
Tobacco	14	84,126	2,536	1,968	9,858	455	1,248	100,191
Tree	8	414	....	....	8,523	250	....	9,187
Sunflower	1	....	....	....	2,618	....	314	2,932
Pyrethrum	1	....	....	....	187	78	....	265
FIELD SEEDS.								
Wheat	5	6,667	5,000	....	1,494	330	610	14,101
Oats	1	320	....	....	294	147	46	807
Corn	3	3,013	764	....	1,991	454	73	6,295
Sorghum	1	822	....	....	1,087	57	....	1,966
Kaffir corn	1	....	321	....	437	78	94	930
Broom corn	1	....	....	....	159	22	....	181
Turnip	12	238,004	81,314	25,436	8,513	1,680	20,526	375,473
Sugar-beet	2	8,601	1,012	217	1,435	279	183	11,727
Mangel-wurzel	3	....	1,376	372	1,056	....	134	2,938
Grass	7	10,043	324	37	4,987	2,014	428	17,833
Clover	4	1,903	149	21	1,621	272	224	4,190
Millet	1	208	....	....	241	....	....	449
Teosinte	1	....	228	46	3,013	510	48	3,845
Forage plants, imported	5	....	416	....	308	32	....	756
TEXTILE.								
Cotton	5	1,497	500	....	1,313	361	....	3,671
Jute	1	....	....	....	47	....	....	47
Ramie	2	....	....	....	51	....	....	51
Grand total	......	3,573,645	301,323	69,525	569,552	17,903	29,793	4,561,741

WM. M. KING,
Chief of Seed Division.

HON. NORMAN J. COLMAN,
Commissioner.

REPORT OF SUPERINTENDENT OF GARDENS AND GROUNDS.

SIR: That portion of the official correspondence of the Department which relates to subject-matters connected with the operations and specialties of this division, and is referred to the Superintendent for consideration and for reply, embraces a variety of subjects upon which advice is repeatedly asked by different individuals; and as the replies made, so far as the Department is concerned, reaches only to the individual addressed, and as this correspondence is largely of general application and directly practical in its nature, I have selected the following from the many similar communications, with a view to lessen repetitions of these particular inquiries:

VANILLA.

S. M. R., POLK COUNTY, FLA.

I understand that the Vanilla Bean grows well in all parts of Mexico, and in cool places. I am sure that it would do well in this county, and would be obliged to you for some plants for trial. Also would be glad to know something about its cultivation and preparing the crop for market.

Answer.—The Vanilla Bean (*Vanilla planifolia*) is a native of tropical countries. It is produced in the warmer parts of Mexico, and not by any means in cool places; in fact, its area of profitable culture is said to be limited to certain favorable localities near the Gulf coast. It is very doubtful, indeed, whether the plant can be grown profitably in any part of Florida.

The Vanilla is a climbing orchid, or air plant, having a fleshy stem and succulent leaves. It is propagated by cuttings of the stems planted close to the trees upon which the plants climb. They usually receive but little of cultivation further than to keep down growths which might interfere with the gathering of the fruit, the plants receiving their nourishment mostly from the atmosphere.

The peculiar odor of the bean is developed during the process of curing, and much of the commercial value of the article depends upon its preparation for the market.

The fruit is gathered before it is quite ripe. If allowed to remain on the plant the pod splits and becomes black; when drying it exudes a dark-colored unctuous liquid, and when quite dry becomes brittle and devoid of perfume.

In Guiana the pods are cured by placing them in ashes until they begin to shrivel, when they are wiped, rubbed over with olive oil, then hung in the open air to dry.

In Peru the pods are dipped into boiling water, then hung out in the open air for a month, afterwards smeared with castor oil, and tied in bundles for sale.

In Mexico the curing process is more elaborate and varied. The pods are placed in a heap under protection from the weather until they begin to shrivel, when they are submitted to a sweating process. This is accomplished by wrapping the pods in blankets inclosed in tight boxes; afterwards they are again exposed to the sun. They are now tied into bundles or small bales, which are first wrapped in woolen blankets, then in a coating of banana leaves, first sprinkled with water, then placed in an oven heated up to about 140° F. Here they remain for from twenty-four to forty-eight hours, according to the size of the pods, the largest requiring the longer time. After this heating they are exposed to the sun daily for fifty or sixty days until they are thoroughly dried and ready for the market.

In the valley of Mazation the Vanilla abounds in a wild state and the article is of the finest grade. The curing is thus described: "To cure properly requires about ninety days, and the manipulation is almost infinite, each bean being handled critically from three hundred to five hundred times in the process by the Indians. The beans, as gathered, are disposed of in layers, first a layer of beans and then a blanket, and so on till a pile is formed. This is called the sweating process, and during its continuance the piles are turned two or three times a day until most of the water is sweated out. This process is followed by drying in the sun, and here the natives exercise the utmost care and attention. When finished the beans are to be the color of a very dark cigar. The attendant picks up each bean occasionally for examination, and if he observes any part of the pod is coloring more rapidly than another he twists a bit of the leaf around the spot until the action of the sun shall have affected all alike."

MAHOGANY TREE.

J. S., EASTERN SHORE, MARYLAND.

I inclose a few seeds of the Mahogany tree which grows in this part of the State. Since I learned that this tree was the mahogany I am saving the seeds and mean to plant all I can get, and would ask you where I can get a supply, as I suppose that the tree is in other parts of this country.

Answer.—The seeds sent are those of the Kentucky coffee tree (*Gymnocladus canadensis*), and has no botanical relation to the tree which yields the mahogany wood of commerce.

It is called the coffee tree for the given reason that the early settlers in Kentucky, where the tree grows in the forests, used the beans as a substitute for coffee.

The timber of this tree is of a fine compact grain and is sometimes used in cabinet work, hence it is in some places called the mahogany tree.

COCHINEAL.

J. H., GUADALUPE COUNTY, TEX.

I take the liberty of writing to you, as I wish to know if you could give me any information about Cochineal. We have here plenty of Prickly-pear (cactus), and I believe it is the same kind used in Madeira for the growth of the insect. I should be very thankful if you would let me know something about the matter.

Answer.—The cochineal insect, *Coccus cacti*, feeds upon different kinds of *Opuntia*, or Prickly-pears. *Opuntia Tuna* and *Opuntia*, or *Nopalea coccinellifera*, are the species principally used in Mexico, and these, with *Opuntia Ficus Indica*, are employed for a like purpose in the Canary Islands, New Grenada, and Madeira.

In arranging plantations or, as they are sometimes termed, nopaleries for raising the cochineal insect, the plants are set out in formal lines, several feet a part, so that they can be cultivated similarly to a carefully checkered corn-field, and when the plants are large enough the insects are distributed upon the plants. These soon give origin to countless numbers of minute insects, of which the females soon increase rapidly in size until they almost lose the appearance of insects and look like small warts. At this stage of their growth they are gathered by detaching them from the plant by a flat wedge-like stick, and placed in a bag, which is then dipped in boiling water to kill the insects, afterwards drying them in the sun.

It has been estimated that 70,000 of these insects are required to make a pound of cochineal.

It may be surmised that the profits of this industry will greatly depend upon the cost of the labor required for these manipulations.

TREATMENT OF LAND.

J. G. T., DELAWARE.

Two years ago I took in hand a piece of ground completely exhausted through continued cropping without manure and so full of wire-worms that not even weeds can be got to grow. The ground is a heavy loam, lying upon a stiff clay; every shower of rain makes it a puddle, and forty-eight hours of sunshine makes it so hard that it is next to impossible to break it up; manure plowed in can be turned up months

afterwards in the condition in which it was put on. I have used lime at the rate of 25 bushels to the acre, but not with the result expected, and intend to apply the same quantity of common salt, in the hope that it will destroy the worms.

Will you kindly say if I have adopted the proper method? and any advice you may tender will be very kindly received and carefully followed.

Answer.—There can be no permanent or satisfactory improvement made upon such land as described until it is thoroughly tile-drained. Thorough draining would involve parallel lines of tiles not more than 25 feet apart, and placed to a depth averaging 30 inches. Then it should be deeply plowed in the fall; fall plowing is an important factor in the management of heavy land, as no mechanical appliances can pulverize it so effectually as the influence of frost.

After plowing in the fall, sow salt at the rate of 15 to 20 bushels per acre, and when it is dry enough to work in spring, spread lime over the surface at the rate of from 50 to 75 bushels per acre and harrow it in before putting in a crop.

It should be well understood that land of this character should never be worked when wet. After heavy summer rains there is always a period between wetting and drying when it can be pulverized on the surface and thus effectually prevent its becoming hard or compact.

Draining will greatly modify the tendency to cake or become hard on the surface. It will also allow of a gradual deepening of the plowed stratum, and is, in fact, the foundation of all improvement towards increasing the productiveness of lands resting upon a clay subsoil.

APPLE TREES.

J. K. E., FAIRFIELD COUNTY, S. C.

* * * Also, I want what information you can give me about apple trees for this climate. I am told that Northern-grown trees, or trees from Northern nurseries, are not desirable, as the fruit will not keep for any length of time during the winter, or after it is taken from the tree. I am comparatively a new-comer here, but would like to set out some apple as well as other fruit trees, and would act advisedly in the matter.

Answer.—So far as concerns the trees, provided they have been well grown, healthy, and wood properly matured, it probably makes but little difference whether they are from Northern or from Southern nurseries; but when it comes to the selection of varieties, especially winter-keeping kinds, it is essential to recognize that most of the Northern winter varieties become summer and fall ripening kinds when grown in South Carolina.

It therefore becomes necessary to procure the best kinds from Southern nurseries, where attention has been given to the propagation of fruit specially adapted to their sections, of which there are numerous varieties, which for size, beauty, and quality, are equal to any produced in more northern regions.

COFFEE.

W. W., ERIE COUNTY, N. Y.

I am desirous of gaining information in regard to the cultivation and raising of coffee.

I should like also to get cuttings or slips of the coffee tree for grafting purposes. I have a ranch in California upon which there is wild coffee growing which produces a berry similar to Mocha, only smaller. If I could get cuttings or buds to graft I should like to make an effort to see what could be done in the matter.

Answer.—The so-called Wild Coffee of California is the seed of a plant belonging to the Buckthorn family, called *Rhamnus Californicus*, and has no more relation to Arabian coffee than it has to a hazel bush or a maple tree.

Of course it would be wholly impracticable to graft or bud the coffee into a Rhamnus and expect the cion to grow.

The Coffee plant, so far as experiments have been noted, has not been a success in California.

The tropical summer period is too short and the winter temperature too low over by far the greater portion of the State. The Coffee plant suffers or is checked in growth when its surrounding temperature is so low as 40° F.

LOTUS PLANT.

H. S., New York City.

Can I get from you a description and sketch of the Lotus plant of Egypt?

Answer.—The Egyptian lotus is given by some authorities as being the fruit of a water plant, *Nymphæalotus.* The fruit of *Nelumbium speciosum*, also a water plant, is also known as lotus.

The fruit of *Zizyphus lotus*, a prickly branching tree allied to the Jujube tree, is supposed to be the true lotus of the Lotophagi. This fruit is described as small farinaceous berries, of a yellow color and delicious taste. This farinaceous substance when dried is pounded into a kind of flour, which, being formed into cakes with water and dried in the sun, makes a kind of sweetish bread.

LE CONTE PEAR.

B. B., Lake County, Fla.

I have about a dozen Le Conte pear trees which have made fine growth, and are bushy trees some 12 to 15 feet in height, but they do not bear any fruit. For several years past a few sickly-looking flowers would appear, but no fruit.

I write to ask you if you think that they need to be fertilized. The soil grows orange trees well; of course they receive some fertilizer, but the pear trees were treated the same.

If you could advise me what to do I would be much obliged.

Answer.—The main reason why the Le Conte pear fails to fruit with you is that the climate is too continuously warm and the trees have no decided or definite period of rest. This continued activity of growth prevents the formation of flower buds, and encourages growth of shoots. If the growth of the plant is arrested or checked in the early fall it would tend towards the formation of flower buds, and possibly secure a crop of fruit. This may be effected by pruning the roots. Practically this operation would consist in digging out a circular trench about 4 feet from the stem of the tree, cutting out all the roots encountered to a depth of 30 inches, then undermine the ball so as to sever all deep-running tap roots. Then throw the earth back into the ditch, firming it properly as the filling proceeds.

If this operation is performed about the end of August it would check longitudinal growth of shoots, and tend towards the formation of fruit spurs on the older branches.

This is not a new or untried process, but has long been practiced successfully in rendering barren trees fruitful, under conditions similar to those here mentioned.

LAWN MAKING.

J. S., Baltimore County, Md.

Now, I want to tell you about my lawn, or rather I should say my failure in trying to get one. Two years ago I had the ground plowed deep; at least my instructions were to plow it deep and good, but I now think that it was not very deeply plowed. It was then made smooth and level; was fertilized with 300 pounds of superphosphate (it is about half an acre), and lawn grass seed sown, and harrowed over. With the bushel of grass seed was mixed about two pecks of oats. It was sown about the end of March, and came up beautiful and green in a few weeks, at least the oats did. When the oats were about to head I was advised to mow them so as to let the grass grow. This was done; weeds came up, but very little grass was seen, and, in short, although the weeds were mown down several times during summer, the grass made no show, and when the most of the weeds were killed by the frost my poor lawn looked very sickly indeed, with here and there a tuft of grass and clover, but the greater portion looked as bare as the day the seeds were sown.

I was advised to cover it all over with a coating of manure just before setting in of winter, which was done. When spring came round, the coarse portions of manure were removed and the finer portions harrowed into the soil. It was again seeded as before, and the oats did well, but not the grass, and I have yet no lawn.

Please tell me why I have failed and how I can get a good lawn.

Answer.—The letter indicates very clearly the cause of failure. First, the soil was probably imperfectly prepared; second, the allowance of grass seed was too

small, and, third, the oat-seed allowance was so large that, even if the other two factors had been of the best, the oat crop would have rendered it a failure.

To secure a good lawn the primary requisite is proper preparation of the soil. Where this can be done by the plow a deep furrow should be thrown out with the turning plow and a subsoil plow run into the bottom of each furrow. This will turn and loosen to a depth of from 15 to 18 inches, according to the thoroughness of the work. If done by hand labor, it should be spaded as deep as the spade can penetrate and the subsoil loosened with a pick, but in no case should the subsoil be brought to the surface if the sowing is to be immediate.

The next operation is to level the surface so that it may be made smooth and regular. No pains or expense should be grudged to make the surface grade perfect at this stage of the work, as it will be difficult to make corrections after sowing.

If good barn-yard manure can be provided a heavy dressing of it should be spread over the surface and plowed in. This soil preparation is best when done in the fall, and the surface left rough during the winter.

Even with the above manuring the second plowing should not be omitted. As a substitute for the fall manuring apply bone dust at the rate of at least one-half ton per acre in the spring on the surface and harrow it in.. Before sowing, the surface should be harrowed and cross-harrowed until a smooth, even surface is produced; then sow the seed, and cover it by rolling.

The best lawn grass is *Poa pratensis*, variously known as blue grass, green grass, and June grass, and the many mixtures sold as lawn grasses are largely composed of this species. A good mixture is two bushels of the above, one bushel of red top (*Agrostis vulgaris*), and one quart of timothy (*Phleum pratense*). This is sufficient for 1 acre, and should be properly mixed before sowing. The timothy seed is included because it vegetates quickly and strongly, loosens the surface soil, and thus facilitates the growth of the other grasses, and soon disappears. If sown under good conditions from 1st of March to middle of April it will be fit for the lawn mower by 1st of June, and by the end of that month will present the appearance of a good lawn.

A fine lawn can not be maintained without frequent mowing, and now that numerous and cheap and efficient lawn mowers are to be found everywhere, there is really no excuse for imperfectly kept lawns.

During the first summer the cuttings of the mower may be allowed to remain on the surface as a mulch, but experience shows that the practice is not to be commended after the first year.

It is pernicious to sow oats, rye, barley, or other grains with the grass seed. These strong-growing plants rob the soil and injure the growth of the lower grasses. They do not require any protection of this kind, and many failures in lawn making can be traced to the practice of mixing these with the grass seeds.

BRAZIL NUT.

W. W. W., IOWA.

I wish to know whether the tree that bears Brazil nuts will thrive in the United States, and whether they will bear much, if any, frost without injury, and whether they will thrive where oranges and almonds do. Also best mode of starting young trees from the nuts.

Answer.—The tree that yields these nuts is the *Bertholletia excelsa*, a native of Guiana, Venezuela, and Brazil. It is found in large forests on the banks of the Amazon, and is therefore strictly a tropical tree, and would not be at all likely to grow to any degree of perfection in Florida.

Climates suited to almonds and oranges are no criterion for tropical vegetation. The former will grow wherever peaches do well, and a bearing orange tree will withstand 10° of frost without injury.

CHICLE GUM.

R. P., NEW YORK CITY.

Among the importations at this port there is an article called Chicle Gum. After considerable inquiry I have not been able to find the name of the plant which produces it, but have learned that it comes from Mexico. If you can tell me the name of the tree or plant, and where it can be obtained, I would try it in Clay County, Fla., where I have interests.

Answer.—Chicle gum is furnished by *Sapota achras*, a tree of the West Indies and of some parts of Mexico.

The fruit is called Naseberry, or Sapodilla plum. It is stated that the succulent gummy pulp surrounding the seeds is named chicle, and that it is employed in the preparation of gum-drops.

The tree will not flourish in Clay County, Fla., although it is to be found growing in the southern extremes of the State, where it has been introduced.

OPIUM POPPY.

C. E., LIBERTY COUNTY, GA.

I have reason to believe that the opium poppy will do well here, and would try it if I had enough seed of the right variety to make a plantation of several acres. Can you furnish seed or procure it for me at my expense?

I should be obliged for any information in regard to its culture, and how best to get the opium from it.

Answer.—So far as climate is to be considered the poppy plant will grow in Georgia, and, indeed, in most of the United States, and seed can easily be secured, and the plants are easily raised. The soil should be very finely pulverized on the surface and the seeds sown in shallow drills, or rather mere marks. The seeds are very minute and should be mixed in fifty parts of dry sand, then sand and seed sprinkled thinly on the surface and covered simply by passing a light roller over them. These drills may be 2 feet apart, and when the plants appear they are thinned out so that they will be from 6 to 8 inches apart.

It is highly improbable that it can be profitably produced in this country, as may be gleaned from the details of collecting the juice.

When the seed pods are properly matured the milky juice is obtained by making incisions in the pods with small lancets. This requires great care, so that the incision is not made through the entire substance of the pod; the surface only is scarified. The cutting being performed in the afternoon, the opium is allowed to exude and remain on the pod till next morning, when it is scraped off, drop by drop, and thus collected in a small cup. Successive incisions are required to secure complete exudation.

It is thus seen that the process is slow and tedious, and it is stated that the average pay of the operators does not reach 10 cents per day.

The factory operations in preparing the article for commerce are also tedious and complicated, involving much manual labor, which is cheaply procured in Asiatic countries.

CAMPHOR TREE.

J. S. R., HERNANDO COUNTY, FLA.

A camphor tree received from your Department six years ago has grown up into a fine tree some 15 feet in height. It is a beautiful ornamental tree, and is valuable on that account alone, but if this is the tree from which the camphor of trade is obtained I would be obliged if you could inform me how to get it. I have tried cutting the bark, but could not see any exudation of gum.

Answer.—The Camphor tree, *Camphora officinarum*, is a native of China and Japan, and yields the camphor of commerce.

Camphor is obtained by chopping the wood or roots into small pieces and boiling them with water in an iron vessel till the camphor begins to adhere to the stirring utensil; the liquor is then strained, and the camphor concretes on standing. It is afterwards mixed with finely powdered earth and sublimed from one metallic vessel into another.

In Japan the chips are boiled in a vessel to which an earthen head containing straw has been fitted, and the camphor sublimes and condenses on the straw. Crude camphor very much resembles moist sugar before it is cleaned; it is refined by sublimation, an operation which requires care and experience.

BAHIA ORANGE.

E. S., PUTNAM COUNTY, FLA.

I have seen a statement that the Bahia orange, as seen in the greenhouse in Washington, has no pollen on its blossoms, and that is given as a reason for its poor bearing in Florida. I would like you to answer me the following questions:

If the want of the pollen is the cause of its not fruiting in Florida, why does it fruit so well in California?

If it has no pollen, how does it happen that it affects trees all around it and causes them to produce Navel oranges?

Answer.—The statement has not been made that because the Bahia orange flowers are lacking in pollen here this variety does not fruit well in Florida, but rather that it does not fruit well there for the same reason, that is, want of pollen to properly pollenize the pistil; this we know to be a fact from personal inspection of trees of this variety when in flower in Florida. Since the first flowering of the Bahia here, quite a dozen years ago, this defect has been recognized. After the fruit became popular in California it was ascertained, by inquiry, that while the trees did not bear so abundantly as many other varieties, yet it produced a fairly profitable crop in that State.

It therefore seems probable that the climatic and cultural conditions permit of a better development of pollen in California than in Florida and in some other places. This would not be an exceptional case. It is well known that climatic conditions affect the pollen of plants. Those who are in the habit of saving seeds know that plants will often fail to set seed in the extreme heat of summer, but will produce fruit and seed abundantly later in the season when the temperature is lower. The reverse of this is also known; some plants will only seed well during the warmest part of the season, and fail to do so in cooler weather. Whether the flowering season of the Bahia in California is more favorable to the ripening of its pollen than is its flowering season in Florida is a point to be determined.

During the month of December and most of the month of January the orange house here is kept at a low temperature, merely excluding frost, and it is also kept dry. Occasionally a stray cluster of flowers has appeared on the Bahia during this period, and such flowers have developed enough pollen to set fruit, which rarely happens in flowers which open in March. This, so far as it goes, indicates some relation between temperature and the production of perfect pollen.

With regard to the question: If this navel orange has no pollen, how does it happen that it affects trees all round it and causes them to produce Navel oranges? it may be stated that this question has been frequently similarly presented for explanation. Presented in this manner it suggests doubt as to the accuracy of the observation of those who have been unable to find pollen in the flowers of this variety of orange; at the same time it furnishes no proof of the existence of pollen on the trees which are stated to exert so powerful an influence upon their neighbors. The question can therefore only be looked upon as an imaginary hypothesis.

The absence or presence of pollen in a blossom is a matter easily determined; a few minutes of inspection would enable the observer to state definitely whether it has no pollen or the reverse.

If the statement is verified that the tree has an abundance of perfect pollen, the cause of non-productiveness would then become a question of further inquiry. This direct evidence of an abundance of pollen would be entitled to a degree of respect which is certainly not afforded by the supposition that because other fruit show a navel mark therefore the suspected tree must have had an abundance of perfect pollen.

The navel mark on oranges is a very indefinite article. Sometimes fruits may be taken from a tree, some of which will have a scarcely perceptible indentation as a mark, while others will show a protuberance half an inch in diameter. The cause of this mark has not been explained. This much may, however, be looked upon as certain, that if a vegetable physiologist picked a fruit having something of a navel mark from a tree of the St. Michael's, or from a tree of Maltese oval, or from one of any variety not known as a Navel, he would not be apt to attribute the appearance of the mark to pollen influence of any kind.

CANARY SEED.

G. M. E., CECIL COUNTY, MD.

I write for information upon the subject of canary seed. I have in view the subject of planting it for a crop if it will grow here and pay. I shall be obliged for what information you can give me as to the character of the plant, the probability of its successful growth here, yield per acre, time of sowing, etc.

Answer.—Canary seed is produced by a species of grass, *Phalaris canariensis*, said to be a native of Asia, but found growing wild in various parts of the eastern world.

But little is known here about its yield or the profits pertaining to its culture. It is stated that the amount entering into consumption annually is about 200,000 bushels, and it is chiefly from Turkey and Barbary.

As cultivated in these countries, the seeds are sown early in spring, in drills 6 inches apart, and the plants thinned to 2 inches apart in the rows. It is a slow-growing, slender-stemmed plant, requiring frequent hoeing to keep weeds from destroying it. Much care is required in harvesting, as the seeds fall off easily; birds are fond of it when it is opening. In some countries the seeds are fed to race horses, as they are said to strengthen muscle without being fattening. No doubt the plant will grow well in Maryland. Probably there would be but little profit in its production. This can only be ascertained from a practical experiment.

TREE-PLANTING.

J. R. E., Fairfax County, Va.

The question as to the best time to plant shade trees or apple and pear trees has been discussed at our club meeting. Some prefer fall planting because the soil becomes well settled about the roots before spring and the trees do much better than those planted in the spring; others maintain that fall planting has no advantages, but on the contrary they have lost trees which were set out just before winter set in, and consider spring planting to be more reliable. Can the Department of Agriculture advise us of the results and conclusions reached on these points?

Answer.—Fall planting is preferable to spring planting because the conditions of the soil and climate are then most favorable. In propagating plants by cuttings it is found that rooting is most successful when the bed in which the cuttings are inserted is 15° or 20° warmer than the atmosphere surrounding them. The heated soil encourages the formation of roots, while the cool temperature prevents bud growths. When these conditions are reversed the cutting will grow for a time without forming roots.

It is found that during the month of October in this locality the soil averages several degrees warmer than the atmosphere. This gives a kind of natural hot-bed into which we place a newly removed tree, the formation of young roots commences at once, and in a few weeks a good system of roots are established, enabling the tree to stand the vicissitudes of winter and make an early and vigorous start the following spring.

If planting is delayed until spring these physical conditions of soil and atmosphere are to a certain degree reversed: the soil is then cold and accumulates heat slowly, while the air rapidly increases in warmth. Trees planted at this time will have the buds excited to growth, and leaves will be formed in advance of the roots; these extract sap from the branches and stem of the tree, which as yet has no active roots to supply this demand. If the weather proves to be dry and warm the evaporation will either destroy the tree or greatly check its growth and well-doing. This is the reason why spring-planted trees occasionally come out into leaf, apparently vigorous and healthy, but will suddenly wither and die under the influence of dry weather.

From the above it will appear evident that fall planting should be performed as soon as the leaves drop. In fact it is most successful when the leaves are stripped from the trees, not later than the middle of October, and planting done at once. If delayed beyond the middle of November in this locality success will be less certain and none of the advantages of fall planting secured. Many failures occur by thus delaying the work, and fall planting is denounced as wrong in practice.

PEAR BLIGHT.

J. D., Kansas.

What effect has the stock on pear blight? The original Kieffer tree is said to be free from blight, and for years it was claimed that all Kieffers were blight-proof, yet of late years we have undoubtable evidence that they do blight. Now, why this change? Is it from foreign sap introduced into the tree through the budding and grafting? First, it was budded on the common pear stock, then cions from that were grafted on another, and so the process was continued until the original sap, we might say, has all been worked out, and as a consequence we have blight.

The Le Conte pear was claimed to be exempt from blight, yet we find in late years that it has blighted. Those who profess to know say that there has never been a case of blight on any tree that can be traced back to the original tree cuttings, but the blight is only on trees which have been grafted.

Now the question arises, are any pear trees blight-proof? and if so can they be kept in that condition by propagating only from cuttings?

Answer.—It may be said that those who claimed that the Kieffer pear would be blight-proof simply made a mistake. As its culture extended and plantations were set out in different localities cases of blight were reported. When the Kieffer comes under the influences which cause blight, it seems to be just as sensitive as many other varieties of its species.

The causes of blight on the pear are not yet understood. The opinion that it is caused by bacteria is quite prevalent, but there are many others who maintain that bacteria is not the cause of the disease, but exists because of the disease; in other words, that bacteria has nothing to do with the origin of disease in plants or animals, but let the animal tissue die and it is in the condition to decompose, and can only do so by bacterial growth. The same with plants. The germs of bacteria swarm in the air, and are always ready to light upon disorganized tissue and perform the great and important task of reducing the vegetable world to its ultimate elements.

Budding upon other than Kieffer stock can have nothing to do with blight. The entire foliage being Kieffer will naturally determine and control the cell growth of the whole plant.

The claims made for the Le Conte pear as being blight-proof rest on no better foundation. Trees of this variety procured from Thomasville, Ga., which were propagated from cuttings, have blighted badly, so badly as to entirely destroy the tree. They have suffered more than the Kieffer under similar conditions; that is, they were growing within 40 feet of each other.

If any variety of pear is blight-proof it has not yet been made known, and it is beyond controversy that pear trees raised from cuttings are just as liable to be attacked by blight as are varieties propagated by any other method.

COFFEE.

W. H. M., SANFORD, FLA.

I shall be pleased to receive, at your earliest convenience, as many coffee plants as you can spare me; also as much coffee seed as you can send.

I have had several years' experience in coffee growing in southern India, and want to try it here, as I think the climate and soil well adapted to successful cultivation of coffee.

Answer.—The Department of Agriculture has for nearly a quarter of a century made yearly distributions of coffee plants, sending them to the warmest localities in the United States, but the returns have not been of a nature to warrant further continuance of the distribution of these plants so far as relates to the object in view of establishing a profitable industry.

It is true that several years ago a small quantity of ripened berries were produced on coffee plants growing near the Manatee River, but it was understood that these plants were in a very well sheltered position, and received additional protection during the severest weather in winter. Subsequently these trees were frozen to the ground by a cold of unusual severity for that locality.

It is quite certain that coffee can not become a profitable crop at Sanford, Fla., where a lowering of temperature down to or below the point of freezing occurs almost every winter. Although the freezing point may not be reached, yet occasional low temperatures in the fall or early winter months retards the ripening of the fruit, even when the plant is apparently uninjured. A tropical climate means something more than mere exemption from frost.

Experienced coffee-growers state that the culture is not commercially profitable in a climate where the thermometer falls below 50° F. at any time during the year. The plant will survive a much lower temperature than the above, but the above estimate refers to the value of the crop.

MUSTARD SEED.

J. W. H., WEST VIRGINIA.

I am using in my business a large quantity of imported mustard seed, and being desirous of raising the seed in this section I write for information as to its culture.

Answer.—Black-seeded mustard, *Sinapsis nigra*, and white-seeded mustard, *Sinapsis alba* are the kinds usually cultivated. The former is said to have the preference for manufacture into flour.

As far as can be learned, there have been but few attempts to cultivate the mustard plant in this country, and the results obtained have not been very satisfactory.

Mustard requires a rich, loamy soil for its growth. It is sown in spring, usually broadcast, although sometimes in drills about 1 foot apart. The soil requires to have a finely-pulverized surface before sowing, so that the seeds may be equally covered by harrow and roller; if they are covered more than one-half inch with soil they may remain dormant for many years. It is found that buried mustard seeds will remain dormant for decades, and vegetate when brought near the surface; so it is difficult to get rid of it in fields where it has once been grown, the seeds shaken out in harvesting being sufficient to furnish a crop, as weeds, for many years.

About one-half peck of seed will sow an acre, and a good crop will return 30 bushels per acre. This quantity is procured only where soil and climate conduce to best results. In dry seasons this amount would be very much reduced.

GRAPE ROT.

J. K., FAIRFAX COUNTY, VA.

My grapes were, I may say, a complete failure this year from rot. Ever since my vines commenced bearing they have suffered more or less, some seasons less than others. Four years ago I may say that the crop was as total a failure as this. Last year I saved a good half crop. I need not say that I am discouraged, and will abandon the culture if this disease continues, but I am loth to dig them up if anything can be done to save them. They have been carefully pruned and fertilized with bone, the land is not poor, and the vines make plenty of growth.

What is the general result of putting paper bags over the bunches? If any particular point in culture or management can modify or extirpate this ruinous infliction I would be glad to know it.

Answer.—As to the general result of putting paper bags over the bunches, it may be stated that it is successful. Some few report unfavorably, but it has been found necessary to place the bunches in bags as soon as the berries are formed, and that, when the covering is delayed much beyond this period, rotted berries have been found in the bags.

It has long been observed and noted that grape-vines protected by a canopy or covering, such as the projecting eaves of a building, or even the casual protection afforded them when growing up through the branches of a tree, are measurably exempt from fungous diseases. Recent reports show that grapes under a board, or even a muslin cover, are almost entirely exempt from rot. A protected grape trellis is described and figured in the Agricultural Report for 1861, and was in use in the garden of the Department for many years, with the best results. This board-covered trellis was substituted by a T-shaped trellis, the flat top being wired, and the vines allowed to cover it with a dense mass of foliage. This arrangement was found to be quite as effectual in protecting from mildew and rot as the more solid but more expensive cover of boards. In this case the more robust growing varieties of grapes were planted at intervals of 30 feet, and trained exclusively on top of the trellis. So far as economy is concerned this plan has an advantage over all others, inasmuch as the vines used for protection also yield their crop of fruit.

Even on the ordinary wired trellis exemption from rot has been observed when the summer growth has been allowed to accumulate on the top wire, and the ends of long shoots and laterals allowed to hang down like a screen over the plants. To secure this heavy top growth summer pruning will be abandoned, which is perhaps an advantage to the crop. Summer pruning, when done at all, is usually overdone, and is but little practiced by the most successful grape-growers.

LICORICE.

P. W. J., ACCOMACK COUNTY, VA.

I would be greatly indebted if you will let me know what you think about the culture of Licorice in this county. Our winters are not quite so severe as at Washington, D. C., and my soil is somewhat sandy. I am anxious to learn something about its cultivation and whether the crop would be a profitable one to raise.

Answer.—So far as regards the cold of winter the Licorice plant will not be injured, but its profitable culture may be considered as doubtful.

To produce good licorice roots the soil must be rich, and it must be deeply worked, at least to a depth of 2 feet. It is very essential to have a deep soil to allow the

downward growth of the roots, which increases their commercial value and enables the plant to withstand hot, dry summers, for if the plants are weakened or checked in luxuriance they are liable to the attacks of the red spider, which destroys the foliage.

The plants are propagated by the slender side roots, which are removed in trimming the saleable portions. They are set in the prepared soil by making a perpendicular hole with a sharp-pointed stick or dibble and inserting the root-slip so that it will be covered entirely, exactly as horse-radish sets are planted.

Frequent hoeing will be necessary during summer, not only to destroy weeds but to maintain growth, and the deeper the culture, without hurting the roots, the better the plants.

As winter approaches the tops will become yellow, and after growth is completed they can be cleaned off and the plants covered with manure.

At the end of the third summer's growth, if the plants have done well, the roots will be large enough for market. The process of digging out and harvesting the roots is perhaps the most tedious operation connected with the crop. They run from 2 to more feet in depth and can only be secured safely by the use of the spade, so that the whole root may be secured without breakage.

The marketable portions are trimmed of all side roots, washed, dried, and tied in bundles for sale.

The labor and cost of manure for thorough preparation of the ground from 2 to 3 feet in depth, the planting and cultivation for three or four years in producing one crop, and the cost of harvesting the roots leads to the opinion that its profitable culture is doubtful, at least while the price of the article remains as at present.

PRUNING GRAPES.

F. M. D., Steuben County, N. Y.

There seems to be quite a diversity of opinions as to the best time to prune the grape-vine. Some prune in the fall and others any time during the winter or spring. Many growers think that there is no particular time better than another so far as fruit is concerned. If the Department of Agriculture has any rule for this operation I would be obliged for information as to the time, and why any particular time is preferred.

Answer.—The best time for the winter pruning of grapes is soon after the fall of the leaves, and the sooner the better, for the reason that the buds will push with more vigor in spring, will bear better fruit, which will ripen somewhat earlier. This arises from the circumstance that the plant during winter continues to absorb more or less of nutriment by its roots, which is distributed in the branches or wood. If, therefore, pruning is delayed until the approach of spring this winter accumulation is largely destroyed and lost. When, however, the vine is pruned in the fall the winter accumulation of increase will be deposited in the buds and parts left after pruning, and such buds will start vigorously and, in consequence of their better development, the fruit they show will be increased, and the shoots will advance rapidly in growth and attain maturity sooner than those from weaker buds, as may be tested by comparative trials and close observation of results.

This becomes a matter of considerable importance in localities where the growing season is barely of sufficient length to ripen the fruit.

TONKA BEAN.

N. B. G., Orange, County, Fla.

Among other tropical plants which I am trying to grow I would like to raise the Tonka bean plant, and would be greatly obliged for some plants or seeds of it for trial, also some information as to the particular value and use of the bean.

I hear of a wild vanilla said to be growing in some parts of this State; would like to know something about it and where seeds or plants can be secured.

Answer.—The Tonka bean is the seed of a tropical tree of Guiana, called *Dipterix odorata*, which reaches to a height of 60 or 80 feet. The bean has a strong odor, somewhat resembling that of cloves, and is due to a principle called coumarine, a fragrant principle found in the dried leaves of the vernal grass, *Anthoxanthum odoratum*, and in the leaves of the yellow melilot, *Melilotus officinalis*. The Tonka bean has been used to scent snuff, hence it is called the snuff bean. It is sometimes employed to adulterate vanilla. It imparts to true vanilla a sharp, rank

odor and taste, which some persons think indicate "strength," but it detracts from the genuine vanilla flavor.

The *Dipterix* would not succeed with you, as it requires a strictly tropical climate.

The term wild vanilla is given to a composite plant of the Southern States, called *Liatris odoratissima.* The dried leaves emit a peculiar odor, also due to the principle coumarine. These leaves are used in scenting tobacco and snuff. This *Liatris* is found in swampy woods throughout Florida, which, with the assistance of a local botanist, you can procure without much trouble or expense.

ZANTE CURRANT.

H. H. M., San Bernardina County, Cal.

I am anxious to test the soil here in producing the "Zante Currant," and desire to know the kind of vine that produces this fruit and where plants can be obtained.

Answer.—The Zante currant is the product of a variety of the foreign grape and will undoubtedly grow where other varieties of *Vitis vinifera* flourish.

It is merely a seedless form of a black grape; the origin or cause of its being seedless has not clearly been explained, except that it results from a deficiency of pollen at the blooming period of the flowers. Similar results are not uncommon with Black Hamburg and other varieties when grown in glass structures; bunches will sometimes fail to be properly pollenized, so that a few berries may reach full size with a more or less percentage of small seedless fruits.

Statements have been made that Zante currants can be produced only in Greece, and that in other countries where it has been tried the plant will produce so many full-formed berries as to depreciate its value as a currant crop.

The plant has long ago been introduced into California and is advertised for sale by various nurserymen throughout the State.

LIME WASH FOR TREES.

E. D. S., Steuben County, N. Y.

I am told that the Department recommends the whitewashing of fruit trees as a cure for blights, yellows, and other diseases. If this is true may I ask what this wash consists of, and how applied so as not to injure the tree. Will not the clogging of the pores in the bark of a tree by a coating of lime or other wash do more harm than good?

Some of my apple and pear trees have blighted to some extent, but I have seen it stated that washing the bark of trees has no effect, either as a preventive or as a cure for blight. Can you inform me on this point?

Answer.—The reports of this Department have nowhere recommended whitewashing as a cure for "yellows and other plant diseases," but frequent mention has been made of the application on pear and other trees as a preventive of blight, at least on the parts covered with the mixture. No harm need be feared in regard to clogging pores in the bark, as there are no pores in the bark that can be harmed by the application.

The wash is prepared by placing one-half bushel of lime and 8 pounds of powdered sulphur in a vessel of any suitable kind, covering with boiling water to properly slake the lime.

The mixture is applied with a brush, covering all parts of the tree that can readily be reached. The most potent ingredient of the wash is the sulphur. The heat of the sun acting upon the wash evolves sulphurous gases which are fatal to bacteria and microscopic fungi, which, as has been demonstrated, are active agents in blight. It is well known that these microscopic spores are destroyed by sulphurous gases and heat is required to evolve them. Sulphur applications are often made for the destruction of mildew on roses and on other plants, but the efficacy of the sulphur depends upon its connection with a certain degree of heat; but it must not ignite. The gases of burning sulphur are fatal to the higher order of vegetation and are speedily destructive to all plants.

Those who have used this lime and sulphur wash on their orchard trees are pleased with the results and have faith in its efficacy in preventing blight.

But it is well to keep in view that, while blight will not maintain upon the portion covered with the wash, the fumes from the sulphur may not be sufficient to prevent blight on the extreme points of branches which can not be reached with

the brush. If blight is discovered on a twig or on a branch it should be removed without delay. With this attention, and covering the main branches with the wash, losses from blight need not greatly be feared.

RHUBARB.

N. E. C., WALTON COUNTY, GA.

I am anxious to purchase a small quantity of seed of the true medicinal Rhubarb. If you will kindly inform me of its botanical name and where it can be obtained, and anything you may know about its culture or preparation for market, you will place me under great obligations. I want the best Turkey rhubarb, or the best commercial kind.

Answer.—Efforts hitherto made by the Department to procure seeds of the best medicinal rhubarb have not been successful. It appears that medico-botanists differ in opinions as to the species of rhubarb which yields the best medicinal root; on the other hand, it has been stated that the roots of the common kinds, grown for culinary purposes under the name of Pie-plant, yield good medicinal roots, and that much of the article in commerce comes from this source.

It is an article of very ancient use. It is said to be mentioned by Chinese writers four thousand five hundred years ago. It is mentioned by early writers as having been brought from beyond the Bosphorus. The Rha, which came into Europe by the ancient caravan routes from northern China, by Bokhara and Asia Minor, was called *Rha-ponticum* and that which came by Russia and Danube was called *Rha-barbarum.* The designations Turkey, Russia, East Indian, and Canton rhubarb merely indicate the commercial channel through which the article has been derived in modern times.

To the species *Rheum palmatum* has been attributed the origin of Persian, Turkey, Russian, and Muscovite rhubarbs, and Chinese rhubarbs are said to be produced chiefly, if not wholly, by *Rheum australe.*

It is now claimed that the true source of the best medicinal rhubarb is *Rheum officinale,* a native of Thibet.

The ordinary species of rhubarb are herbaceous perennials, with a thick root stock and deciduous leaves. In *Rheum officinale,* after the third or fourth year of its growth from seed the root-stock gradually decays and a stem is formed above ground from which roots are emitted to support the plant. These stems have thick branches, often 6 to 8 inches in diameter, and are the parts used in medicine, and not the rhizome or root.

It is considered that very much of the difference of appearance and quality of commercial rhubarb is largely owing to the time of lifting the root and the care given in its preparation for market. The roots are in many places taken up early in autumn; the Chinese dig up the roots early in spring, just before the leaves appear.

When the roots are lifted they are first divested of all small fibers, then thoroughly cleaned by washing. After drying in the sun for several days they are cut in thin slices, and after a further due exposure to the sun a hole is bored in each slice and strung on a thread until properly dried.

The pieces are then put through a finishing process by being placed in a close cylinder where they are subjected to abrasion by the rapid revolution of the vessel. This smooths their surfaces, liberating at the same time a fine dust or powder which envelops each piece with a fine bloom, like that upon the surface of a ripe plum.

There is no reason to doubt that the root if grown in the warmer climates here would be equal to the best, provided species which yield a good article could be procured. Its culture is simple and its preparation easily accomplished.

GINSENG.

P. W., ALBEMARLE COUNTY, VA.

Has the Chinese Ginseng plant been cultivated in this country? I would try it if I knew where to purchase seed. If you can give me any information as to how seeds or plants can be had and how it is cultivated I will be obliged; also, would like to know the probable profit of the crop.

Answer.—So far as can be learned ginseng has not been successfully cultivated in this country. It is a product of the woods, and efforts made in its culture have not proved satisfactory. Chinese ginseng is closely allied to our native species;

seeds have occasionally been received from China and Japan, but so far as ascertained they have not vegetated. It is possible that they soon lose their germinating power, as, it is stated, the Japanese deposit the seeds in the ground as soon as they are collected, in order to keep them fresh until wanted to sow.

The Japanese cultivate the plant to some extent, and their method is to select a sheltered position and make a bed of leaf-mold in which the seeds are sown, and where the plants remain until they are ready for use. These beds are protected from the sun by a roof of straw laid on poles, which are supported on posts. After growing four years the roots are lifted, carefully washed, scalded in boiling water, then dried in a high temperature until they become brittle. The best article sells for about $5 a pound in Japan. It is a plant which does not submit readily to culture, and its production as a profitable crop would be very doubtful.

HORSE-CHESTNUT TREE.

B. D., Oswego, N. Y.

I understand that Horse-chestnuts are raised in considerable quantities in France, and are used as food for horses, cattle, and hogs to fatten them. The nut has a bitter taste, and it is said that the French people use some kind of alkali to kill this bitter taste and thus make it palatable to their cattle. I wish to find this out, and my reason is that in this city and county horse-chestnuts are grown for shade trees, and thus large quantities of the nuts are grown and go to waste, and we want to know how to use them. Also, the wood is white and could be used for fancy work and finishing furniture. Have you data on the utilization of the Horse-chestnut tree?

Answer.—The nuts of the Horse-chestnut tree, *Æsculus Hippocastanum*, contain about 20 per cent. of starch, but contain a bitter principle, which makes them unpalatable to most animals, although it is stated that goats, sheep, and deer eat them. They are sometimes boiled, which reduces the bitterness, and are then fed to poultry. When the nuts are dried and reduced to a coarse flour, the bitterness is removed by simply washing the flour with water. A paste made with this flour before washing is used by book-binders and pasteboard manufacturers, its bitterness saving it from the attacks of insects. The bitter principle is called esculin.

The following products are obtained from the nuts in France:

(1) An alkaline lye from the burnt-seed vessels.

(2) A charcoal from the skin of the nut, which forms the base of different printing inks.

(3) From the amylaceous pulp the fecula is extracted, which can be transformed into dextrine, glucose, alcohol, or vinegar.

(4) A fatty matter, which serves to make a kind of soap, and which also is employed to render certain mineral colors more fixed and solid.

(5) A yellow coloring matter, which serves for various purposes of dyeing.

(6) The ashes of the burnt nuts contain 75 per cent. of potash.

(7) The bark has been used as a substitute for cinchona.

(8) Tannin is found in all parts of the tree, leaves, bark, and fruit.

(9) Water in which the nuts are boiled is used for bleaching hemp, flax, and other fibers.

INDIA GRAINS.

M. H. N., Texas.

During a residence in India I became acquainted with several kinds of grain which are superior to anything grown in this country as feed for stock. These grains are grown in the dry regions, and for that reason I think they would be specially adapted to southwestern Texas. There is a kind called Gram grown in central India, and in southern India another kind also called Gram. These are ground before fed to stock. Then there is a grain called Bajery, which is used for making bread, of which the yield per acre is very large.

The Department might procure these seeds through the consular service or from merchants in Bombay. If they can be secured I will have them tried in southwestern Texas and make known the result.

Answer.—The word Gram is used in India to designate various kinds of peas and beans grown for food, just as we use the word grain to designate various useful seeds. Among the species known as Gram the following are noted: *Cicer arietinum*,

Phaseolus of many kinds, *Dolichos uniflorus, Soja hispida*, and various species of *Vigna*, which are largely grown in the Southern States under the name of Cowpeas. These, however, are not peas, they are small beans.

Bajery or Bajree is a name applied to the seeds of *Penicillaria spicata*, which is well known here as Pearl Millet, and may be procured from most dealers in agricultural seeds in the United States.

SEEDLING ORANGES.

M. E. R., Frederick County, Md.

I have three orange and one lemon tree in tubs; the plants are about 4 feet high; the lemon tree is the tallest; they have not had any blossom, and I am told that before they will flower they must be cut down and grafted ; but the plants are so fine, and I value them so highly, having raised them from seeds planted by myself, that I will be very sorry to have them cut if it can be helped. Please inform me if it is true that they will not flower unless they are grafted.

Answer.—Undoubtedly they will flower without being grafted. Probably one-half of all the fruit-bearing Orange Trees on this continent have never been grafted; but they seldom blossom until they are eight to ten years old, unless under special treatment. This special treatment consists in what is technically known as "stunting" the plant, or allowing it to become "pot-bound," thus retarding its growth for want of nourishment, which in all cases tends to the formation of blossom buds, and checks the growth of wood. But this must not be carried so far as to interfere with the general health of the plant, because it would then have a tendency to produce disease.

Orange Trees are grafted or budded only when it is desired to extend, by propagation, any particular variety.

The Orange reproduces itself from seed more closely than most varieties of tree fruits, but no dependence can be placed upon this mode of reproduction for absolute similarity in all of the essential qualities. But budding or grafting has a tendency to hasten the flowering period, and the operation is often performed for this purpose on the Orange where it is grown only as an ornamental plant.

PEEN-TO PEACH.

B. F. G., Wilmington, Del.

I have applied to several nurseries for plants of the Peen-to peach, but have not been successful. In reply to my last application I was informed that the variety would not live in Delaware, and also that the fruit was small, bitter, and not worth having.

This does not conform to what I have heard about the fruit as grown in the South, where it is claimed to be the earliest and best peach they can grow. What is the experience or knowledge of the Department on this tree and fruit?

Answer.—The Peen-to peach will not do well in your climate; the winters are too severe for it.

As to the fruit it is, when well grown, not above medium size, and when fully ripened on the tree is of fairly good quality for so early a fruit, but if gathered before full maturity it has somewhat of a bitter taste.

In portions of Florida, where the common peach rarely bears fruit, the Peen-to is the earliest and best peach they grow, and it will undoubtedly be the parent of a class of trees particularly suited to that climate. It is stated that already seedlings of the Peen-to have been procured which prove to excel the parent both in size and quality.

INDIGO.

H. S. B., Sanford, Fla.

I should be much obliged if you could give me any information as to the planting, fertilizing, and preparation of Indigo, and also if it would flourish in this soil and climate.

Answer.—The Indigo plant, *Indigofera tinctoria*, is a native of Asia, but has been cultivated in many parts of the world. Indigo was at one time an article of export

from South Carolina and other Southern States, but its production in the States has long ceased to be of commercial importance.

The plant requires a moderately rich soil, the seeds being sown early in spring, sometimes broadcast, but preferably in shallow drills about 16 inches apart, so that weeds can be removed or kept down by hoeing. The plants will be ready to cut in about three months after sowing the seeds. They are cut just before coming into flower, and if conditions of growth are favorable a second crop may be cut in about two months afterwards.

The coloring matter does not exist as indigo in the plant, but when the plant is steeped in water and subjected to certain processes the blue color is educed.

As soon as the plants are cut they are thrown into vats of water, where they are allowed to remain until sufficiently macerated. The liquid is then drawn into another vat, where it is subjected to agitation by beating with rods for several hours, or until the water changes from a greenish to a deep purple color. It is then allowed to settle. The water gradually clears and the indigo sediment is found on the bottom of the vat.

It is then boiled, strained through bags, and otherwise treated until prepared for commerce.

All the processes require careful, skilled treatment to secure the best results.

Indigo was produced near Saint Augustine prior to the year 1760, and records show that it was cultivated in Virginia about 1680.

There seems no reason to doubt its adaptability to the climate of southern Florida, provided the seed is sown in deep rich soil, but it is somewhat doubtful that it would prove to be a profitable crop.

NAVEL ORANGES.

From Putnam County, Fla.

As there seems to be an uncertainty about the proper distinction regarding navel oranges, I would be pleased to have you inform me whether or not the Bahia, Washington navel, Riverside navel, and Parsons navel are all one kind. Also, would like to know if any of these were ever sent to Florida by your Department.

Answer.—Of the above the only variety of the navel orange sent out from this Department was the Bahia. This variety was imported from Bahia some years ago, and to designate it from other navel oranges the name of Bahia was attached to it. Young plants of this variety were distributed in California and Florida about the same time, but mostly in Florida, where there are now large trees of first distributions. However, the conditions of climate, probably, in California seemed to suit the variety better than Florida. At all events, its value there soon brought it into notice, and as it first fruited at a place named Riverside it received that name, also that of Washington, thus ignoring the name on the label attached to the plant when received.

As to the variety known as Parsons Navel, this Department has no knowledge of its origin.

With regard to the distribution of the Bahia from here, as between California and Florida, many more have been sent to the latter-named State.

NETTLE FIBER.

From South Carolina.

I wish you would advise me of any improvements or developments that have been made recently in the preparation of nettle fiber. Our country is overrun with nettles, and it would be a blessing if they could be put to some use.

Answer.—The Department is not aware that nettle fiber enters into commerce to any extent. Ramie, one of the best fiber plants of the nettle family, has considerable commercial value, but the expense of its preparation for market has, hitherto at least, prevented its profitable culture, although machinery for its profitable preparation has lately been announced.

EUCALYPTUS TREE.

From York, Pa.

I have seen it stated at various times that *Eucalyptus globulus* trees were being planted in the public grounds in Washington on account of their supposed power to prevent malarial emanations from the soil.

Desiring to plant a shade tree in front of my house, I desire to ascertain whether the Eucalyptus is likely to thrive well in this climate.

Answer.—The *Eucalyptus globulus* has not been planted in the public grounds at Washington.

The tree is altogether too tender for this climate. It will not withstand more than 5 or 6 degrees of frost, and has been killed by cold at Galveston, Tex., and in Florida as far south as latitude 29°.

PERUVIAN TEA.

E. H., NORTH CAROLINA.

Can you furnish me with any plants of the Peruvian tea or mate for experiment here?

Answer.—The plant which yields the leaves used as tea in Brazil and Peru is *Ilex paraguayensis*, a large-sized tree which would not grow in North Carolina.

It seems unnecessary to ignore the Chinese tea-plant, *Camellia thea*, which will grow well in most parts of North Carolina, and contains more theine than the Peruvian plant.

BLACK PEPPER.

A. C. P., PORTLAND, OREGON.

If possible, I should like to be supplied with seeds of the Black pepper tree or vine from the most northern latitude where it flourishes. I would try the experiment of raising it in the warm valleys of southern Oregon.

Answer.—The Black pepper vine, *Piper nigrum*, is a tropical plant, and therefore it would be futile to expect it to grow in any part of Oregon; it requires even a warmer climate than either the Pine-apple or the Banana, neither of which can be cultivated profitably in Oregon.

RAMIE.

B., NEW YORK.

Can Ramie be successfully grown in this State?

Answer.—Ramie can be grown in New York State by lifting the roots during the fall, and preserving them all winter, like potatoes. But for commercial purposes this process would not be profitable, unless the profits on the crop were greater than they are at present. South of Maryland the plant occupies the ground like clover, and once planted no renewal is needed for many years.

MAHWAH TREE.

A. P., SOUTH CAROLINA.

I send you a slip from a newspaper which strongly advocates the introduction of the Mahwah tree from Africa, as a sugar-producing plant of more value than any other sugar-plant now in cultivation. Please send me some seeds or plants for trial here, or inform me where they can be procured.

Answer.—The Mahwah tree, *Bassia latifolia*, is a native of Bengal and other highly-tropical districts in the East Indies, and it is far from probable that it would flourish anywhere in the United States, but certainly it could not stand the climate of South Carolina. The flowers of this tree are sweet to the taste, and are eaten raw by the natives of Guzerat and in other places where the trees abound. A fiery kind of spirit is distilled from the flowers.

The sugar of these flowers is mainly uncrystallizable. Analysis of sun-dried flowers yield 56 per cent. of sugar and 15 per cent. of water; further analysis showed that sucrose (cane sugar) was only present in the proportion of 3 per cent., while glucose (lævulose and dextrine) yielded 52 per cent. Hence it can not possibly be substituted for cane or beet sugars. Of nitrogenous matters the flowers contained 2 per cent. The usual proportion of useful nitrogenous food should have one part of flesh formers to five saccharine; but in the Mahwah flowers it was only two to fifty-five, hence these have but little of nutritious value.

OSAGE ORANGE.

L. B. C., MISSOURI.

I write to ask if you can tell me of a way to destroy the osage orange hedge fence. This is becoming unpopular among the best farmers on account of the cost of trimming, making it hog-proof, and its taking the substance of the ground for such a wide space each side of it. Cutting it, letting it dry, and then burning will not do, as it will sprout again from the old roots.

Answer.—The best method of destroying the hedge is to cut the tops of the plants so that the remaining stock and roots can be grubbed out, and the more effectually these are removed the less trouble will result with suckers; but when these do appear they should be hoed out as other weeds are destroyed. Plowing the ground deeply for several feet of each side of the original hedge line will break and bring to the surface some of the roots, every fragment of which should be removed. It will not be practicable to get rid of every piece of root at once, but if timely attention is given to the removal of such growths as may appear, the whole will eventually be eradicated.

Respectfully submitted.

WILLIAM SAUNDERS,
Superintendent of Gardens and Grounds, Horticulturist, etc.

Hon. NORMAN J. COLMAN,
Commissioner.

THE NATIONAL HORSE OF AMERICA.

By Leslie E. Macleod, *Associate Editor of Wallace's Monthly.*

In essaying to write of the national American horse, in order to the better establish an understanding between the reader and the writer it is essential to outline the ground to be covered, the phases of the subject to be touched upon, and the extent to which each can be considered. In attempting to deal, in the space of a few pages, with a subject that could only be adequately and comprehensively discussed in a large volume, we must first choose certain divisions of the subject to which our attention will be directed, for it is patent that we can not here discuss so large a topic in all its aspects. Then, when we have determined our divisions, we must again prescribe further limits of detail. With these remarks at the outset, the reader will understand why I shall not attempt to treat any single point with fullness or minuteness, but shall rather discuss each division of the subject in its leading features alone, and with that degree of generalization necessarily involved in considering a large subject in small compass. And I must explain, too, by way of preface, that I write for the general reader, not for the professional breeder, to whom probably all I shall say will prove familiar.

The division that is the simplest will best suit the purpose. The subject will then be divided and considered something in this order: (1) Definition. (2) Origin and history. (3) Principles of breeding, characteristics, value, and uses of the distinctively American horse.

The thoroughbred race-horse may with propriety be called the national horse of Great Britain. There he has reached his highest development, and if the race-horses of other countries have excelled it has been through liberal draughts of English blood. In like manner, but in greater degree, the trotting horse is the national horse of America. He is distinctively and peculiarly an American production. The evolution of the trotting breed has been but an incident in the development of the Republic. In no other land has the trotter been generally bred; in no other land has he been brought to high development as a breed; nor in any other land has he been accepted and utilized as specially and superiorly adapted to the every-day uses of the people. It is true that Russia has her Orloff trotters, that writers speak of "Norfolk trotters" in England a century ago, and that in France, Austria, and Australia native horses race at the trotting gait. Though vastly superior to any trotter of foreign origin—or perhaps it would be more correct to call him the only trotter of foreign origin—the Orloff does not hold the place in the affairs of the Russian people held by the American trotting-bred horse in the

affairs of the American people. He is not generally bred and used. As to the "Norfolk trotters" of England, the more that is learned of them the less certain can we be that it is at all correct to regard them as a breed of trotters. Should we array all that is known of these horses, we could only show that some of them had speed at the trot far superior to that of the ordinary English horse, and proving this we have not by any means proven that they were a trotting breed, but rather have established that they might have been suitable raw material from which, by selection and development through a series of generations, to evolve a trotting breed. As to the "native trotters" of Europe and the "native trotters" of Australia, they must be regarded in discussing breeds as yet in too embryotic a state to be seriously considered.

The facts, then, that the fast-trotting horse is distinctively an American production; that of all our breeds of horses the trotting horse is the only one that we can claim as peculiarly American; that he fills with the American people a range of uses that no other breed or variety can fill; and that he is bred in America to an extent unapproached by other breeds, are ample justification for the public acceptance—and for my definition—of the trotting-bred horse as the national horse of America.

I will defer comment upon his excellence in special capacities until we have done with the historical division of our subject; but I wish here to explain that when I define and treat the trotting horse as the national horse I do so considering him not chiefly as a turf horse—a racing animal—but regarding him in his higher capacity as the special horse of the people. Still, in tracing his history, in estimating his capacities, and in weighing the relative merits of the different strains of blood that enter into this composite breed we must deal in a very great measure with his turf history. The horse best adapted to the uses of the American farmer and the average American citizen who uses horses at all is the one that, with other essentials, combines quick, far-reaching, well-balanced action with the endurance to sustain speed at high rates and long distances. These are, too, the qualities primarily required in a horse for racing purposes, and thus the blood best for the trotting turf is the best blood from which to breed the horse of the road, the park, and the boulevard—the horse for the lightest single driving equipage, for the family phæton, or for double harness. Qualities required for these eminently proper purposes are produced in the highest degree by the best trotting blood; we can only determine what the best trotting blood is, by the measure of turf tests and turf history; and though these qualities may be, and we know are, ofttimes shamefully perverted upon the track, they are none the less essential and none the less to be desired in the horse we are discussing. The fact that high and excellent capacities are perverted to ignoble uses renders them none the less to be admired, valued, and striven for. Further on I propose to say a word as to the benefits of proper racing. Here I only wish to impress upon the reader who may have no interest in the American trotter in a turf sense the fact that the value of the light-harness horse rests in a large degree upon the purity and quality of his blood, and that the worth of his blood can only be determined by what it has accomplished under the turf test. Hence the occasion for considering turf history.

To every one accustomed to horses the differences of the various gaits are familiar, but to fix them clearly in the mind is a first neces-

sity in studying the subject of breeding horses in which value depends on speed at a certain gait. The walk, the trot or the pace, and the gallop are gaits common to all breeds. The pace, or amble, is a gait kindred to the trot and is a faster gait than the trot. The order of movement in the trot is left fore foot, right hind foot, right fore foot, left hind foot. Thus the left fore and right hind foot move in unison, striking the ground together; then in turn right fore foot and left hind foot complete the revolution, and therefore the trot is properly called the "diagonal gait." The pacer, like the trotter, moves two feet in the same direction simultaneously, then alternates with the other two, but in place of the fore leg and the hind leg of opposite sides, he moves in unison the fore and hind leg of one side, then the fore and hind leg of the other side. Thus we call the pace "the lateral gait." The difference of the gaits is not great; the mechanism is practically the same. The fact that the same animals pace and trot fast, that pacing parents beget trotting progeny, and *vice versa;* and that both gaits seem natural to the same animal demonstrates that they are but variations of one gait, occupying in the economy of action a place between the walk and the gallop. The more closely one studies the relation of these variations of gait the less surprising to him will appear the part pacing blood has played in establishing a breed of trotters. The fast gallop, or run, is an entirely different gait; each leg acts, as it were, independently. To begin the revolution the horse makes his bound with the left fore foot the last to leave the ground; then for a moment he is entirely in the air, with his four feet rather bunched, and when he strikes ground again it is first with his right hind foot; then a moment more and he is poised on the left fore foot, as at the beginning of the revolution. It will be seen that this gait is wholly and radically different from the pace and trot; that the order of action and necessarily the mental organization governing the method of locomotion and use of the limbs are different. Hence no one horse is, or can be, possessed of great speed at the gallop and also great speed at the trot or pace. To possess great speed of either one of these two orders he must inherit speed of that order.

As we are indebted to England principally for the nucleus of our breed of trotters, it will be of interest to note very briefly such transatlantic horse history as has a bearing upon the subject.

The origin of the Orloff, though his blood has not a part in our American breed, is of interest, that being the fastest of foreign trotting breeds. In 1772 Count Alexis Orloff, a commander in the Russian fleet, obtained from a Turkish pasha a large, white Arab or Barb horse called Smetanka. From a Danish mare Smetanka got Polkan, and from a Dutch mare Polkan got Barss, the founder of the Orloff trotters. It will be noted that Barss was two removes from the oriental horse and carried one-quarter of his blood. The fact has been commented upon that Andrew Jackson, the founder of our Clay family of trotters, was similarly bred; that is, he was two removes from the imported Barb, Grand Bashaw, and, like Barss, out of a mare of unnamed blood. Count Orloff, it appears, bred the Barss blood upon itself, and a writer, speaking with the apparent assurance of one who knows, tells us that "the race became a distinct type in about thirty years, and since that period all attempts to improve the breed by fresh blood, whether Arab, English, French, or Dutch, have failed." This can readily be believed, for in our own horse history we find its corroboration and analogy. Count Orloff died in 1808, but

his stud was kept intact until 1845, when it was broken up, the Russian imperial Government becoming the owner of the greater part. The blood and performances of these horses have been carefully recorded. The highest rate of speed known to have been attained by an Orloff was in trotting 3 versts in 5 minutes. A verst being 1,166⅔ yards, it will be seen that the performance was at the rate of a mile in about 2:31½. Though some specimens of the Orloff trotter were brought to the United States, meeting trotting blood superior to their own, they naturally failed to leave their mark on our breed.

The only reputed trotters mentioned by English writers were certain horses located chiefly in the county of Norfolk. John Lawrence, the earliest writer who mentions them, and a most entertaining one, declares that "the renowned Blank may be looked upon as the father of trotters, since from his son Shales have proceeded the best and greatest number of horses of that qualification." Blank was a son of the Godolphin Arabian whose romantic and mysterious career we are told touched at one time the degradation of hauling a cart in the streets of Paris, though at last he achieved fame as a mighty sire of English race-horses. As will be seen later on, however, Shales was probably by Blaze and not by Blank. One of the most famous of this tribe was Marshland Shales, a noted trotter that sold for over 3,000 guineas at auction in 1812, when ten years old. In writing of these horses a quaint old writer describes Marshland Shales as "the best in Mother England." Records of their speed are indefinite and uncertain, but it is said that a mare named Phenomena trotted in July, 1800, 17 miles in 56 minutes, and in the same month repeated the performance in 53 minutes. If this be true, this mare was the superior of any American trotter, not of her day alone, but for many years after her day. When we remember that this was at the rate of 20 miles in 62⅓ minutes, and that it was not until 1849 that Trustee, in America, covered 20 miles in 59:35½, the conclusion is forced upon us that the English had the material from which to build and evolve a great breed of trotters. That they have nothing equal to Phenomena in these days is certain, and the cause of this retrogression is probably that the trotting instinct and action in the horses of the olden time has been submerged by repeated infusions of running blood, just as the ancient English pacer disappeared before the tides of oriental blood upon which the English thoroughbred is founded. The chief and, indeed, only interest attaching to the Norfolk trotter is in the fact that it is practically certain that Imported Bellfounder, the sire of the dam of Rysdyk's Hambletonian, the greatest of all American trotting progenitors, was one of this tribe. This horse was imported from England in 1822, and was a powerful animal with gigantic quarters, showy trotting action, and kindly disposition. Hambletonian bore much resemblance to him in form and disposition.

The foreign horse that played the most important part in originating the American trotting breed, and that figures in the ancestry of our greatest sires and performers, was Imported Messenger. Ever since trotting speed first began to be considered a mark of merit in the American horse, ever since trotting blood was talked of, the blood of this horse, Messenger, has been unanimously considered the chief foundation stone on which the greatest trotting families have been built. Just as the English race-horse was founded on oriental blood, and in years of selection and development for a special purpose was bred to a point of excellence unknown to the oriental,

so the most unpretentious trotting blood of to-day is superior to what the direct blood of Messenger was. It is with writers on horse-breeding a very common but very erroneous thing to inculcate the idea that because some family of horses originated in a famous ancestor he was necessarily superior to his descendants of the present day. They forget that in forming a breed we rise superior to as we go away from the beginning. A stream meandering from a mountain spring may be the source of a great river; but if we follow that stream we find it joined by tributary after tributary until the aggregated whole is a mighty volume compared with which the source is insignificant. So the speed-transmitting power of Messenger, if it could be now drawn upon directly, would be a weak and sluggish element in the swift and intense speed currents of to-day. Still, none the less did it play its part as an original source.

Messenger was a gray horse, foaled in 1780, bred by John Pratt, of New Market, England, and, according to the English Stud Book, was got by Mambrino out of a daughter of Turf. Mambrino was by Engineer, son of Sampson, by Blaze, by Childers (Flying Childers), son of the Darley Arabian, a horse imported to England from the Levant in the reign of Queen Anne. Turf, the reputed sire of the dam of Messenger, was by Matchem, son of Cade, by the Godolphin Arabian.

Here two points present themselves for consideration, or perhaps we should say, speculation:

First. Mr. J. H. Wallace, founder and compiler of the American Trotting Register, than whom no man has worked more indefatigably in the interest of the American horse, than whom none has accomplished more, and than whom none is a better authority has quite clearly demonstrated that Messenger was not a strictly thoroughbred horse. Engineer, the sire of Mambrino, sire of Messenger, was not thoroughbred, and, under the technics of breeding, this of itself puts Messenger outside the pale of race-horses of untainted blood. Then the evidence that his dam was a daughter of Turf is wholly unsatisfactory, and in short, even if all stated in the Stud Book is admitted, still under no rule, English or American, could Messenger be ranked as thoroughbred. It may be said he was practically thoroughbred; but when we reflect that he did that in founding a trotting breed which no thoroughbred horse ever did, we are almost irresistibly forced to the conclusion that in the streams of unknown and uncertain blood pouring into his inheritance some subtle influence was carried that favored the trotting gait. Indeed, this is not speculation, but certainty; for in Pick's Turf Register we find this striking and positive statement concerning Mambrino, the sire of Messenger: "Mambrino was likewise sire of a great many excellent hunters and strong, useful road horses. And it has been said that from his blood the breed of horses for the coach was brought nearly to perfection."

Another point, speculative rather than certain: I have already given John Lawrence's statement that Blank "may be looked upon as the father of (English) trotters, since from his son Shales have proceeded the best and greatest number of horses of that qualification." But in his history Lawrence admits that the statement that Shales was by Blank is merely tradition. In the introduction to Vol. I of the English Hackney Stud Book Henry F. Euren, a most candid and entertaining writer, pretty satisfactorily demonstrated that Shales was a son of Blaze, the sire of Sampson, that got Engineer, sire of

Mambrino, the sire of Messenger; and if, as is very probable, Bellfounder, the sire of the dam of Rysdyk's Hambletonian, was a descendant of Shales, there was a remote consanguinity between the male and female lines of Hambletonian's inheritance. Euren tabulates the pedigree of Blaze, and remarks, "There would appear to be a large proportion of English blood in the dam of Blaze, though no one can say what was its character, whether running, trotting, or ambling." And, commenting further, he reasons:

The fact that in the seventh generation from Blaze, on each side, the reunion of the blood in Rysdyk's Hambletonion, the sire of so many fast American trotting horses, should have proved to have been of the most impressive character, would appear to warrant the conclusion that there was a strong latent trotting tendency in the ancestors of one, if not on both sides of Blaze.

I do not attribute much importance to the influence of remote crosses, except in one sense—the historical importance of that influence as a starting point, from which it, meeting kindred and strengthening crosses through successive generations, rises at each remove, stronger, better, and infinitely superior to its origin.

Messenger was imported to Philadelphia in 1788; was kept in Pennsylvania and New Jersey for the first six years of his life in America, and was variously kept on Long Island, in Dutchess, Westchester, and Orange Counties, New York, and in New Jersey until his death, near Oyster Bay, Long Island, in 1808. As to what degree of trotting action Messenger possessed we have no evidence; but this much is certain, that he left progeny noted for their speed and endurance on the road, and when in these descendants this road gait was developed and intensified by use, and they were mated with a view to producing progeny superior in this special qualification to themselves, each generation naturally reached a higher plane of excellence than its predecessors. "It was," says Mr. Wallace, "the crowning glory of his twenty years' service in this country that he left a race of driving horses of unapproachable excellence, and as he inherited this quality from his sire, so he imparted it to his sons and they in turn to theirs until we have to-day from this stock the fleetest and stoutest trotters in the world." And herein lies the importance of Messenger, and to this extent only: He furnished sterling "raw material" from which to mold a trotting breed; and the breeder of the high-class American horse of to-day can regard Messenger blood much as the jeweler who works a triumph in gold may be supposed to regard the rough nugget.

Though in the second and third generations we find many descendants of Messenger noted as trotters in their time and figuring frequently in the trotting genealogies of our day, it is incompatible with the purposes and extent of this article to consider any but the chief lines, those upon which the place in history of Messenger's blood as a source of the greatest trotting families chiefly depend. These three sons—chief sources—we will consider in the inverse order of their importance: Winthrop Messenger, Bishop's Hambletonian, Mambrino.

Winthrop Messenger was taken to Maine in 1816, and was the founder of that sterling race frequently spoken of as Maine Messengers. He was a large, coarse horse, and was, I judge, very little appreciated in his time. Among his best descendants was his son Witherell Messenger, sire of Belle of Portland, 2:26. A daughter of Witherell Messenger, mated with a son of his, produced the famous Belle Strickland, 2:26. Six other daughters figure in the records as the dams of trotters with records faster than 2:30. Fanny Pullen,

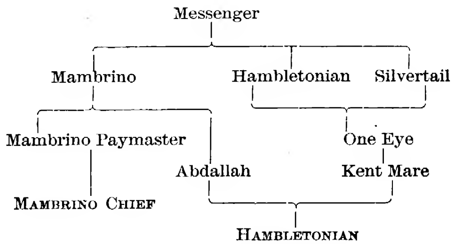
daughter of Winthrop Messenger, was a great trotter in her time, and to Imported Trustee she produced the famous Trustee that trotted, in 1848, 20 miles in 59:35½. He was the first horse to trot 20 miles within the hour; to this day only six have done it, and it is earnestly to be desired by every decent horseman that no horse will ever again be subjected to this cruel exaction. A course parallel to that which produced Belle Strickland brought State of Maine, a horse of some merit. He was got by a son of Winthrop Messenger, out of a daughter of Winthrop Messenger. Through numerous other channels much of the best horse stock of Maine trace to Winthrop Messenger.

Bishop's Hambletonian, originally called Hamiltonian, was a bay horse, foaled 1804, bred by General Coles, at Dosoris, Long Island, and was by Imported Messenger out of Pheasant, by Imported Shark. He was as a race-horse quite nearly first class, especially at long distances, being successful at 4 miles. He was the best of all Messenger's progeny as a race-horse, if we except Miller's Damsel, the dam of American Eclipse. As a sire of trotters and trotting progenitors he won distinction. One of the most gifted of early turf writers, who wrote with singular severity of this horse, conceded that "he got some excellent roadsters, good trotters," but probably in so speaking of the race-horse the writer meant to be anything but complimentary.

Among the progeny of Bishop's Hambletonian the most distinguished on the trotting turf were the famous Whalebone and another early trotter of less note, Sir Peter. In 1830 and 1831 the former ranked with the best of his day as a long distance trotter, and has to his credit a performance of 32 miles in 1:58:05. Daughters of Bishop's Hambletonian produced Paul Pry and Topgallant, both being by other sons of Messenger, and they were the first trotters of their time. The latter trotted 3 miles in 8:11 in 1829. The most noted progeniters of trotters left by Bishop's Hambletonian were his sons Harris's Hambletonian and Judson's Hambletonian. The former sired Green Mountain Maid, 2:28½; Lady Shannon, 2:28½; Hero, pacing record, 2:20½, and others of less note. A son of his sired Joker, 2:22½, and six of his daughters have produced trotters. Major Edsall, the sire of Robert MacGregor, 2:17½, was out of a daughter of Harris's Hambletonian, as was also Cuyler, Stillson, and other sires of note yet living. Judson's Hambletonian was less distinguished than Harris's, but his blood enters into several lines, the most prominent being through his son Andrus's Hambletonian, the sire of the trotting mare Princess, that, after meeting the best campaigners of her day from the Pacific to the Atlantic, made still more firm her rank in the records as the dam of Happy Medium, one of the greatest trotting sires the world has yet produced.

Coming to Mambrino, in a trotting sense the greatest son of Messenger, we reach the keystone of our subject, for from his loins came two lines, the greatest in all trotting history. One son of Mambrino gave us the sterling Mambrino Chief family of trotters; another got Rysdyk's Hambletonian, far and away the greatest of all trotting progenitors. The latter founded a trotting family with which none other can compare and to which none approach, and his blood has, it is truly said, "raised the trotting horse of America to the highest point of excellence." Mambrino Paymaster, son of Mambrino, sired Mambrino Chief, the founder of the Mambrino Chief family; and Abdallah, son of Mambrino, sired Rysdyk's Hambletonian. To show the descent of these two heads of the chief trotting families, to demonstrate their closeness in blood, and to trace them in the direct

line to their common source the following tabulation, or "genealogical tree," will suffice:



It will be seen that, while Mambrino Chief traced directly in one line through his sire, Mambrino Paymaster, and *his* sire, Mambrino, to Messenger, Hambletonian was in a somewhat remote degree imbred to Messenger; besides the line through Abdallah, and his sire, Mambrino, he traces to the head of the "tree" through his dam, the Kent Mare, whose dam was One Eye, daughter of Bishop's Hambletonian, son of Messenger. The dams of Mambrino Chief and Abdallah were mares of unknown blood, and the possible influence of these unknown mares in giving their sons the trotting force they had should not be ignored. But these are merely historical considerations, not matters for practical consideration for the breeder to-day.

Mambrino was a bay horse, foaled 1806, bred by Lewis Morris, Westchester County, N. Y., and was by Messenger, out of a daughter of imported Sour Crout. He never raced and was so little valued that history loses trace of him for part of his career. He died in Dutchess County in or about 1831. He was a large, coarse, leggy horse, with well-defined trotting action.

His son Abdallah was bred by John Treadwell, Sailsbury, Long Island, and was foaled in 1823 by Amazonia, a trotting mare of unknown blood. He was an unattractive rat-tailed horse, of vicious temper, and was little valued at any time. So lightly was he thought of in Orange County, so a writer states, that he wintered one year, within sight of the spot where his son Hambletonian afterwards lived in honor, with no better shelter than the leeward side of a haystack. Finally cast off, he was given to a Long Island farmer, who sold him to a fisherman for $35. The fisherman tried to harness him, but age had not subdued his ungovernable spirit and he rebelled with such violence that he was turned out and died of neglect and famine on the sandy beaches of Long Island. This was in November, 1854. He had trotted a mile in 3:10, it is stated, as a four-year-old, and considering that he never was broken, that this was his natural gait, it must be conceded he had some gift of speed.

Abdallah, as we have seen, got Rysdyk's Hambletonian out of the Charles Kent mare, by Imported Bellfounder, a reputed Norfolk trotter, and the Kent mare's dam was One Eye, by Bishop's Hambletonian, son of Messenger. Besides this greatest of trotting progenitors, Abdallah got three trotters with records of 2:30 or better; many of his daughters produced trotters and sires and dams of trotters, and others of his sons contributed in minor degrees to trotting lines.

Hambletonian was foaled in 1849, and was that year bought, with his dam, by William M. Rysdyk, of Chester, Orange County, N. Y.,

who owned him until he died. He was a bay horse of excellent structure, but very plain, the large head and Roman face especially rendering him objectionable to the eye of the lover of form. Mr. Rysdyk never was anxious to show the speed of his horse, but that he possessed fair trotting capacity abundant evidence from many witnesses demonstrates. As a three-year-old he trotted in public in 2:48, and, considering the time and circumstances, it marked him as a great natural trotter. This world-famous progenitor died March 27, 1876.

It calls for a large book of records to tell in detail what the Hambletonian family has accomplished on the turf. I shall only be able to give an idea of its triumphs in general terms and numbers. Forty of the sons and daughters of Rysdyk's Hambletonian have made trotting records ranging from 2:17¼ to 2:30. One hundred and three sons of Rysdyk's Hambletonian have sired 494 trotters with records ranging from 2:08¾ to 2:30. Thirty-nine daughters of Hambletonian have produced 45 trotters with records of 2:30 or better. His greatest sons are Alexander's Abdallah, Aberdeen, Dictator, Edward Everett, Electioneer, George Wilkes, Happy Medium, Harold, Jay Gould, Masterlode, Messenger, Duroc, Middletown, Sentinel, Strathmore, Sweepstakes, and Volunteer. These are not only great sires, but most of them the heads of great subfamilies. To follow these several lines downward through successive generations with any degree of fullness would be wearisome to the reader not specially interested in speed production, and would involve an array of statistical tables not within the scope of this article. In general terms, however, it may be stated that the Hambletonian subfamilies founded by Alexander's Abdallah, Electioneer, George Wilkes, Happy Medium, Harold, and Volunteer are the most highly esteemed, because the most productive. Alexander's Abdallah got Goldsmith Maid, 2:14, the greatest of campaigning mares, and he got Almont, one of the greatest trotting sires of any age, and Belmont, little less noted, he having produced Nutwood, 2:18¾, and Wedgewood, 2:19, both renowned on the turf and in the stud. George Wilkes was a king of the turf in his day, and to-day holds a higher rank as a trotting progenitor than any other horse, living or dead, if we except Hambletonian himself. He is the sire of more turf performers than any horse, and his sons evince the same speed-producing power. The other sons of Hambletonian just named are in varying degress less famous, but they are all esteemed equine kings.

Mambrino Chief, the head of the family that ranks next to that of Hambletonian, was foaled in Dutchess County, N. Y., in 1844, and was got by Mambrino Paymaster, son of Mambrino, from a mare whose blood lines are lost in the "mists of the West." She produced also Goliah and the Livingston horse, trotters of respectable capacity, and whatever her blood may have been she added to that of Mambrino Paymaster a quickening and fructifying element. Mambrino Chief was a fast trotter. "He was never in the hands of a trainer, yet he could trot in 2:32, and doubtless in the hands of a trainer could show 2:20 far more easily than many of the great trotters of our own day." Mambrino Chief got 6 trotters that made records of 2:30 or better, the most renowned being the famous Lady Thorn, 2:18¼; 23 of his sons sired 75 trotters, and 15 of his daughters produced 19 trotters. His best sons were Woodford Mambrino, 2:21¼, Clark Chief, and Mambrino Patchen, brother to Lady Thorn. The blood of Mambrino Chief, like that of the Clays, American Stars, and, it may be

said, all other trotting branches, has reached its greatest triumphs when blended with that of Hambletonian and his sons and daughters.

The Champions, a sterling line of less note, are also descended from Mambrino, son of Messenger.

The Clay family of trotters was founded by Andrew Jackson, a trotter of high class in his day. He was a son of Young Bashaw, son of Grand Bashaw, a Barb imported from Tripoli in 1820. Young Bashaw's dam was by the race-horse First Consul, and his grandam was by Messenger. The dam of Andrew Jackson was a mare of unknown blood that, it is said, both trotted and paced. Andrew Jackson was foaled 1827 at Salem, N. Y., and died at Knightstown, Pa., in 1843. His most noted sons, as trotting sires, were Henry Clay and Long Island Black Hawk, and some of his get were creditable performers. From Henry Clay we have the line of sires known through several generations by the name of Cassius M. Clay, and two other sons of Henry Clay, besides the original Cassius M. Clay, are known as sires of trotters. Cassius M. Clay, 1st, got George M. Patchen, the most famous horse of the Clay line and founder of a valued family.

Other noted sires of the Clay line are Cassius M. Clay (22); his son, American Clay; Harry Clay, son of Cassius M. Clay (20); the Moor, and his son Sultan, etc. The dam of old Henry Clay was Surrey, a Canadian trotting mare of unknown blood. The whole Clay family has been charged with a lack of stamina, a charge unduly pressed and exaggerated, and some theorists imagine they find an explanation in the blood of Surrey. Be this as it may, Clay blood as an auxiliary to Hambletonian strains has produced the grandest results.

Long Island Black Hawk was a trotter and a sire of trotters of some merit. The best line from him is through the great Iowa horse, Green's Bashaw, grandson of Long Island Black Hawk. The dam of Green's Bashaw was a half-sister to Rysdyk's Hambletonian, she being out of the Charles Kent mare by Bellfounder.

The next noted family of trotters, the Black Hawks, frequently called Morgans, properly originated in Vermont Black Hawk, a horse whose breeding has never been satisfactorily established and is still seriously questioned. The generally accepted version is that he was got by Sherman Morgan, son of Justin Morgan, a pony-built horse of unknown blood, from whose loins came an excellent class of road horses. The descendants of Justin Morgan had the showy, trappy gait, conformation, and other characteristics that find their counterpart in certain Canadian families, and after duly weighing all the facts presented as to his history, I think the most reasonable conclusion is that he was of Canadian descent. It is of little importance, however, as his family (excepting the Black Hawk line, if that line really does belong to it), the Morgan family proper, hold no rank as a trotting race, albeit they were good, stylish, useful horses for the road and every-day uses, without the qualities essential to prominence on the turf.

Vermont Black Hawk, the true progenitor of the so-called Morgan family of trotters, was foaled in 1833, near Durham, N. H., and, as I have said, is represented to be by Sherman Morgan, out of a mare from New Brunswick, Canada. Whatever his dam may have been, and the version just given is of questionable authenticity, she undoubtedly played the major part in giving to Black Hawk the degree of trotting capacity—mediocre, it is true—which he possessed. He was able to trot close to 2:40, and his reputed sire, if

witnesses speak truly, "could not trot fast enough to go to mill." From Black Hawk comes the Ethan Allen family, the General Knox family, and other less prominent lines. This trotting line reaches its highest plane in the family of Daniel Lambert, son of Ethan Allen. Daniel Lambert must be ranked little inferior as a producer of speed to any horse that ever lived. He is still alive, though over thirty years of age, and has the distinction, since the death of Happy Medium, of having to his credit more trotters with records of 2:30 or better than any horse now living. His family has undoubtedly suffered through injudicious crosses. Had his blood been better reinforced with the Hambletonian strain, supplying certain essentials which in itself is lacking, grander results would have been produced. It is important to note that Daniel Lambert's dam was a daughter of Abdallah, the sire of Rysdyk's Hambletonian, and from this fact, coupled with the knowledge that he is infinitely a better horse than his sire, and moreover far better than any horse of his family, the reader can draw his own conclusion as to what influence his dam exerted in making him what he is.

The other broken and scattered groups descended from Black Hawk need not be noticed in detail, all being of minor importance.

Now I have briefly outlined the origin of the four chief trotting families—the Hambletonians, the Mambrino Chiefs, the Clays, and the Black Hawks. Of course I have left innumerable minor lines untouched, but I can not well complete a sketch of the principal elements entering into the trotting blood of to-day without touching upon the groups of families of pacing origin. In attempting to set aside and classify the families of pacing origin by themselves one can but approximately draw the line of demarcation, for it can not positively be asserted just to what extent pacing blood is intermixed in the foundation lines of trotting blood. We can not assert positively that Hambletonian and Mambrino Chief did not carry pacing blood, for might it not have been carried in the one case through the unknown dam of Mambrino Chief, in the other through the unknown dam of Abdallah? I do not say it is probable; I only point the possibility. That the Clay family had a pacing strain is pretty generally admitted; that the Black Hawk family carried the blood of the Canadian horse is strongly probable; so that in grouping the chief families of pacing origin together, I can not say that none other than these had pacing strains, but can say that the trotting strains now to be considered certainly proceeded from known pacing fountains.

It is useless to discuss the origin of the pacing gait, for even as horses trotted and as horses galloped so horses paced at a period "whereof the memory of man runneth not to the contrary." On the frieze of the Parthenon at Athéns the hand of the sculptor left time-defying evidence that the pacer was known in Greece when she was at the zenith of her glory, four hundred years before the Christian era. The bronze horses of St. Marks in Venice were cast (probably about the beginning of the Christian era) in the pacing attitude. During the Roman régime in Britain we are told the *ambulatara* was "perhaps the universal and traveling pace of the Romans." Fitz Stephen, a monk of Canterbury, writing in the twelfth century, tells us that at Smithfield, then a suburb of London, on Fridays "shows were held of well-bred horses exposed for sale," and he adds that it was "pleasant to see the nags, with their smooth and shiny coats, smoothly ambling along." In 1558, Master Blundeville, one of the

early English writers on the horse, said: "Some men have a breed of great horses, meete for the warre and to serve in the field, others breed ambling horses of a mean stature, for the journey and to travel by the way. Some againe, a race of swift runners to run for wagers," etc. In the reign of Charles II a great impetus was given to racing, and continual importations of Eastern blood flowed into England. The race-horse was forming as a breed and took the first place in the affections of Englishmen. Before the overwhelming tides of desert blood the pacer gradually became extinct in England, until John Lawrence tells us, in 1809, that "the people have lost all remembrance of the amble." Indeed, it is the popular belief, wholly untenable, however, that the pacer never was known to exist in England. At the time of the founding of the American colonies the pacer was at least popular, if not esteemed patrician as in the early days; and as the horse stock of the colonies came chiefly from England, I think it is beyond question that in these importations came the ancestors of the American and Canadian pacer. The horses of Rhode Island, known as "Narragansett pacers," attained wide celebrity in the seventeenth century, and the pacer was the race-horse of the Rhode Islanders and Virginians of the olden time. They were one of the great staple products of Rhode Island at that day and were largely exported. But in time, as the colonies grew in wealth, the pacer was scattered and crowded out by larger, better horses, a race more acceptably suiting the requirements of the people.

The names of the families of pacing origin most frequently encountered in the choice blood lines of our modern trotters are the Pilots, the Blue Bulls, the Columbuses, the Hiatogas, the Copper-Bottoms, etc.

The originator of the Pilot family was a black pacing horse that, according to tradition, and tradition only, came from Canada, and was probably foaled about 1826. He is famous as the sire of Pilot, jr., a gray horse of much merit as a trotter and sire of trotters. The blood of his dam is unknown. He evinced the rare power to get trotters out of running mares, and two of his fastest and best were out of mares so bred. Though he sired nine trotters with records ranging from 2:24 to 2:30, and although some of his sons, notably Bayard and Tattler, have proved successful sires, it is through the triumphs of his daughters as brood-mares that he is most esteemed. Thirteen of these have produced twenty-six trotters with records of 2:30 or better, and among the produce of Pilot, jr., mares are the two fastest trotters yet produced—Maud S., 2:08½, and Jay-Eye-See, 2:10.

The marvelous pacing horse Blue Bull is the phenomenon of trotting-horse history. "A plebian of the plebians," got by a horse on whom the atrocious name the family bears was bestowed as a mark of opprobrium, a cripple with not a line of distinguished blood to lend him worth, from the uses of an ignominious office he rose in his day, by sheer force of merit, to the front rank of trotting sires. This remarkable horse was foaled in Switzerland County, Ind., in 1854, and died at Rushville, that State, in 1880. He was wonderfully fast at the pacing gait, and even after being crippled could show great flights of speed. For several recent years he has figured as the sire of more trotters than any horse that ever lived, and it was only during 1887 that that honor passed from him to George Wilkes. Fifty-two of his get have records ranging from 2:17¼ to 2:30. At present, while we can rank Blue Bull as a very great sire of speed, I am not very sanguine that the future will rank him a great progenitor. His own

lack of breeding and the lack of breeding in the mares to which he was bred are against the chances of his tribe taking high rank as a family. Still, taking the individual himself (although I regard him as a phenomenal transmitter of speed rather than as a great progenitor of trotters and sires of trotters) it must be conceded that in some respects he was the most remarkable horse of his time. In estimating the rank of Blue Bull as a sire, in his favor it must be remembered that by his own merit he forced himself, under the most untoward circumstances and in spite of prejudice, out of the very depths of obscurity into the front rank of trotting sires. Rich lineage did not attract to him fleet and pure-blooded matrons. He made his reputation in an out of the way country town, and he got speed with unsurpassed uniformity upon the coldest of "cold" blood. Only two or three of his performers are out of mares of any degree of good breeding, and under such circumstances he transmitted speed so well that for a time he had more trotters to his credit than any horse that ever lived. To say this of Blue Bull is full justice, and only that.

Of the other pacing families mentioned, the Columbuses are of Canadian origin. The original Columbus came from a town in the province of Quebec "30 or 40 miles below Montreal." From this same mysterious region came St. Lawrence, another Canadian trotting sire, and to the blood of that district is traced lines in many of our famous trotters. I should like to know the truth as to the original stock of that part of the province of Quebec. That there were there long ago horses of the true trotting gait and instinct is undeniable.

The Hiatoga family traces to early Virginia pacing ancestry. The first noted horse of the line was taken to Fairfield County, Ohio, about 1840, is known as Rice's Hiatoga, and from him the trotting family of this name is descended. The Copper-Bottoms, a noted pacing family that figure in many trotting pedigrees, were, like the Columbuses and probably the Pilots, it is believed, of Canadian origin. The original was, according to the Trotting Register, taken from Canada to Kentucky in 1812.

Another Canadian family that may or may not have been of kindred blood to those just named, but a family far superior to any other of Canadian origin, is that bearing the name of Royal George. The founder of this line was Tippo, a horse whose blood is unknown. I quite recently attempted to learn something further about this horse, but like many who have already investigated, I could ascertain little that is new. His son, Black Warrior, got Royal George, and from this line a really good trotting family has been produced.

A tribe that has held a foremost place in turf history as a cross for Hambletonian blood was that of American Star, a horse that flourished previous to and in the early part of the career of Rysdyk's Hambletonian. The pedigree of this horse is extremely doubtful, but he was a trotter of some merit. From great numbers of his daughters bred to Hambletonian a goodly number of trotters came, but the family lacked the capacity to transmit speed potently from generation to generation, and its only standing as a trotting line rests upon what Hambletonian accomplished upon its daughters.

Other sources and minor branches of trotting families there are innumerable, but I have touched upon the chief fountains from which came the currents blended in the trotting breed of to-day. Now, after a brief paragraph or two on the subject of the progress in speed made by the trotter, the historical part of my sketch will close, and we will conclude with remark upon the principles on

which the trotter is intelligently bred, his general usefulness, and cognate aspects of the subject.

The first recorded trotting performance in America was that of Yankee, at Harlem, N. Y., July 6, 1806. The time of the mile was 2:59, but the track was not a full mile. At Philadelphia, August, 1810, a "Boston horse" trotted the mile to harness in 2:48½, but the next best performance I find is in 1818, and then the time is only 3:00. To estimate the progress in speed made by the trotter in consequence of his being bred for his special purpose we must approximate his extreme speed at the beginning of the founding of the breed. If we take for granted that Yankee could trot in 3:00 in 1806, in contrast with the 2:08¾ of Maud S in 1885, we have a difference of 51¼ seconds in seventy-nine years. But it would be erroneous to conclude that the extreme speed capacity of the trotter of to-day is over 50 seconds to the mile faster than that of the trotter of eighty years ago. Improved tracks, appliances, and methods have accomplished much. If we could approximate just how much of the improvement in speed is due to the improved tracks, appliances, and methods, we could then give to improved blood its share of credit. Guarding, then, against the error of giving all the honor to superiority of blood, let us note step by step the improvement in the extreme speed of the trotter.

From the performances above noted, I think it fair to approximate the extreme speed of the trotter previous to 1820 at 2:50 to the mile, in harness. From that date recorded performances are plentiful and furnish us a safe guide. In 1829 Topgallant went 3 miles in 8:11, and this sustained speed at the rate of 2:43⅔ is certainly better than 1 mile in 2:40. In 1834 the black gelding Edwin Forrest went a mile under the saddle in 2:31½; in 1839 Drover paced in 2:28. In 1844 Lady Suffolk trotted under saddle in 2:26½; in the same year Unknown paced to wagon in 2:23. In the next decade Flora Temple trotted in 2:19¾, and in the same decade the marvelous pacing mare Pocahontas went the mile to wagon in 2:17½. The stars of the following decade were Dexter, 2:17¼, and Lady Thorn, 2:18¼. In the next period Goldsmith Maid, 2:14; Hopeful, 2:14¾; Rarus, 2:13¼; and Lula, 2:14¾, represented the limits of trotting speed. St. Julien trotted in 2:12¾ in 1879, but reached his limit, 2:11¼ the following year. In 1884 Jay-Eye-See astonished the world by trotting the mile in 2:10, but the next year Maud S., by trotting in 2:08¾, set a mark of speed in harness not since approached. The pacer Johnston, by doing the same task in 2:06¼, demonstrated that the lateral gait is still the fastest.

But we have been dealing in the performances of phenomenal animals. I will now, by taking the average of the five fastest performances for each decade since 1820, show what may fairly be called the extreme speed of the trotting horse and his gradual gain in speed since the beginning of fast trotting:

Average extreme speed:

1820 to 1830	2:42
1830 to 1840	2:35¼
1840 to 1850	2:28½
1850 to 1860	2:25
1860 to 1870	2:18¾
1870 to 1880	2:14
1880 to 1887	2:11½

The question as to what rate of speed the trotter will ultimately attain has been much discussed, and some have assumed to fix the

limit. This is the merest speculation. A concensus of the public opinion of horsemen in 1860 would have fixed the limit of the trotter's speed at Flora Temple's mark. When Ethan Allen, harnessed with a runner, went the mile in 2:15 men thought it would never be equaled, and the popular opinion certainly was that no horse could do it alone. Only a little over twenty years ago it was timidly that Hiram Woodruff ventured the forecast that Dexter would beat Flora Temple's record; but to-day a gap of eleven seconds is opened between Flora Temple's record and that of Maud S., and upwards of one hundred and forty horses have surpassed Flora's performances. In view of the fact that the trotting breed is yet in its infancy, and that the average of extreme trotting speed is steadily advancing toward two minutes, I think it rather absurd that men assume to fix a limit and a time when progress will suddenly cease.

At the outset I explained why I should deal pretty fully with the turf history of the trotter, while still considering him chiefly as a horse whose great value consists not wholly in turf uses, but rather in his adaptability to serve the requirements of the American people. The greater a road or park horse's natural speed is the greater his value, and it is value we breed for after all. Whatever may be the views of the reader as to the other influences of the trotting track, he must admit that it has been the chief agency in bringing the American light-harness horse to a point of excellence unrivaled and unapproached by any other breed. The love of the turf is deeply rooted in America as well as in England, and I think this devotion to "the sport of kings" is greatly due to an eminently proper feeling that the improvement of the higher kinds of horses depends mainly upon turf tests. "It is certain," says an old English writer, "that horse-racing was the means of converting the old lumbering horse of this country into the elegant, graceful, and pre-eminently fleet animal of * * * the present century." This applies as well to our beautiful trotting-bred horse of to-day. The true horseman deplores everything that tends to degrade the turf more sincerely and deeply than do the Pharisees, who ignorantly rail against the horse and the test instead of against the men who practice abuses. Excessive betting, and indeed gambling, are undeniably practiced on the turf, but men bet on all affairs of doubtful issue as well. Shall we therefore silence the public voice lest wagers be made on what the verdict of the ballot-box may be? It is absurd to demand that an honorable public amusement, serving as well the production in higher form and value of a great staple of our commerce be abandoned because unworthy men participate therein. Prime essentials of horses in their highest form are speed and endurance, and how can their speed and endurance be adequately tested except by putting them in contest? The farmer who breeds a beef cow, or the coarser varieties of horses for more menial service than between the carriage shafts, contests for premiums with his neighbor at the county fair. Shall his brother who breeds for the speed that is essential to his chosen horse be tabooed for likewise seeking the honor of a premium in his class—a certificate of the triumph of his endeavor to produce an animal of special excellence? But argument on this point is superfluous, for every person of entelligence recognizes the use, and indeed the absolute necessity, of the track test. Without it our high type of fleet and beautiful horses of great price would degenerate into as luggish, lumbering spiritless tribe of little worth.

The value of the trotting-bred horse has been constantly on the increase, until now the breeding business is a vast interest to which unlimited capital is devoted. That the trotter should be in America a more valued breed that his brother aristocrat, the thoroughbred, is natural. If the thoroughbred race-horse fails to develop the speed, stamina, and disposition necessary to success on the turf he is almost worthless. He is a good racing machine or he is nothing. But on the other hand the trotter, even if he lacks the capacities essential to success on the turf, is still, if bred wisely, valuable. For the family carriage, for the park, for the road, for the farm, his versatile gifts make him profitable even though he fails on the turf. When I speak, therefore, of the trotter the reader will remember that I refer not always to a racing animal, but to a light-harness horse, that is only produced in the best form when trotting-bred.

Very seldom has a better test of the relative value of trotting and running (or thoroughbred) horses been offered than in October, 1886, when two great breeding studs, one of thoroughbred, the other of trotting horses, were dispersed under the hammer. At Louisville, Ky., the late John C. McFerran had founded and established the Glenview stud, which rose to the front rank of "nurseries of trotters." At Jobstown, N. J., Mr. Pierre Lorillard's Rancocas stud of thoroughbreds, the choicest in the land, was situated. Dispersal sales were held of these famous collections within a few days of each other, and the following averages were realized:

RANCOCAS THOROUGHBREDS.

Average for stallions	$6,390.00
Average for brood-mares	1,422.27
Grand average for stallions and brood-mares	1,721.62

GLENVIEW TROTTERS.

Average for stallions	12,780.00
Average for brood-mares	1,678.00
Grand average for stallions and brood-mares	2,288.75

These prices, it must be remembered, represent the values, as determined by the public in 1886, of the most fashionable blood, and of course either of trotters or thoroughbreds only those bred in lines of blood renowned on the turf would realize prices approximating these.

The very first question confronting the practical man contemplating a profitable business in horse-breeding is, "What is the most profitable horse to breed?" I think the most profitable horse for any man to breed is the one he understands the best. But to the breeder that is not an expert in any particular branch, beyond doubt the most profitable class of horses are those salable for roadsters, for city and general driving. This is the horse that most eminently fits the title "light-harness horse." He should be large, say about 16 hands high, with substance, fair speed, good disposition, and beauty. The horse to possess all these qualities combined in one valued whole is produced from trotting blood. If we are not breeding especially for speed we need not of course particularly select the most fashionable blood. In almost any trotting-bred animal sufficient speed for the purpose will be found. The selection should be directed chiefly to securing size, style, docility, form, and qual-

ity. Still, it is well not to forget that the rule is, the better the blood the better the horse, and the better the pedigree the more money your horse will bring in the market. To breed this class of horses does not call for large expenditures. In almost every county in the land can be found some trotting-bred stallion of good size and individuality, available at a moderate fee. Mares suitable to produce the horse we are discussing can be secured at prices not above their intrinsic value; if he breeds a sound, handsome, trotting-bred mare to a stallion of equal qualifications there is hardly a possibility that, intelligently managed, the transaction will not result profitably to the average American farmer. Though the time may come when ultra-fashionable trotting blood will not sell for the seemingly fabulous prices of to-day, there is not the slightest doubt that a fine-blooded driving horse of size and beauty will always sell at a price making his production profitable. To the general farmer and small breeder, then, I would say, breed the horse that is the surest always to bring a paying price, for then you reduce the risk of loss to the minimum; then the profit is most sure, depending upon the intrinsic worth of the animal rather than upon the shifting fashions in blood, or the uncertain chances of distinction on the turf. You are breeding for business, not for sport. Select a sire of sufficient size and solid, good color, with trotting action of a high order, well-bred, handsome, and stylish in the family carriage; fast enough for the road; strong enough for all purposes of the farm; with the right kindly disposition for all the purposes of a family horse, and with nerve and speed enough for all the purposes of the gentleman driver. Now, get a mare approximating this standard, and you are in a position to breed the most valuable, the most useful, and the most profitable horse that exists. He will draw the plow, or haul a load to market, or perform any task better, infinitely better, than a heavy, sluggish animal. Then put him in the family carriage and he will challenge the admiration of all who see him floating along in the pride of his beauty. There is satisfaction, enjoyment, and profit in this horse, for he is elegant, beautiful, and useful in all places. Such horses are always in demand and always salable at a remunerative price in keeping with the form, size, style, speed, and breeding of the individual. Beauty, size, and style are the first considerations in breeding this peerless carriage horse. No matter what the speed or pedigree of a stallion may be, if he has not good size and substance, and does not carry himself magnificently and stylishly, he will not do to breed the ideal carriage horse from. Breeders who can afford to breed for speed alone may patronize fast but undersized stallions, but a small breeder can not afford to do it; and, indeed, I doubt if any one can afford to do it. If a small horse is a phenomenal trotter he is worth something; if his speed is only that of an average horse he is a "losing speculation."

See that you get size ranging from 15.3 to 16.2 hands and weighs from 1,100 to 1,250 pounds. The most profitable horse is within these bounds. The favorite color is solid bay with black points, and lofty carriage and elastic gait are essential. The conformation of the highest type of the trotter is the best, with clean limbs, fine coat, and the general characteristics of good breeding.

It is strange, yet true, that some misguided but generally very estimable people look upon speed (and necessarily good breeding) as undesirable in a horse. If a horse can do anything else well, does it not add to his value to have the ability to draw the carriage fast?

One to sell for road purposes for $500 to $1,000 must have a fair degree of speed, and to have a fair degree of speed he must have a fair degree of breeding. So that, while being careful to secure first the size, style, and beauty, the better bred your horse is, the more pure trotting blood you get in him, the better. This may be accepted as an important truth in regard to breeding this grand type of horse: After the requisite size and style is secured, the better the trotting blood the greater the value of the horse. But while having due regard to speed, size and beauty must be first aims, and they should not be sacrificed to any other consideration. Other things being equal, the fastest and best-bred carriage horse is of course the most valuable, so that the wise breeder will seek, while keeping up the physical standard, to strengthen the trotting inheritance and improve the blood. It is still always well to remember that the men who make money breeding trotters are they who aim first and constantly to breed trotters, and he who would succeed in breeding carriage and park horses will aim first and constantly to breed carriage and park horses. Have a purpose in breeding, and breed true to that purpose.

Breed a mare that approaches your ideal of what the horse you seek to produce should be to a stallion the nearest to that ideal. Breed to a horse of size, substance, and beauty, whose progeny demonstrate that he gets size, substance, and beauty uniformly, and that they are characteristic of his blood. Breed to a horse that is above the suspicion of unsoundness in any particular. Breed to a horse of good action and good speed, whose colts are pure and positive in their gait, and breed to the horse that with all these qualities combines a strong trotting inheritance, and you can not fail to produce horses that will command remunerative prices for the park and the road and be a source of pleasure and profit in whatever sphere they are used.

Although it has often resulted profitably, I do not conceive it to be wise or judicious for the ordinary farmer or small breeder to embark in the business of producing horses purely for turf purposes. But if he aims to produce a turf horse, and still, in accordance with the courses advocated above, protects himself by so selecting breeding stock that the offspring will, whether with speed sufficient for the turf or not, still pay more than the cost of the production, he is certainly not increasing the risks any, and certainly is increasing the chances of very large profits. This involves grading up to the most fashionable trotting blood, while preserving great excellence of structure, which should be an aim with every breeder, great or small, pursued with an energy and enterprise shaped to his circumstances.

To produce a horse with the special capacity of turf fitness calls for a knowledge of the principles of breeding, an acquaintance with blood lines and their characteristics, and a familiarity with the qualifications necessary in turf horses, their production, and development, which few men have the opportunity of acquiring. Breeding for trotting speed is a special and it may be said professional line of animal production, and unless a breeder be a very close student of the subject, with a thorough mastery of the records and of all theories and practices of breeding, it will be wise for him to leave the production of horses the profit in which depends on their fitness for the turf to those whose special business it is, and who are specially equipped for it. The fortunes of the turf are, at best, uncertain.

Every breeder of domestic animals should feel an obligation to himself to master the cardinal principles underlying reproduction of desired qualifications in stock, and in conclusion a brief résumé of these central principles seems in order. I do not propose to deal minutely with the complexities of the subject or to discuss theories, unless a plain statement of certain principles of natural law may seem to combat or support certain theories of breeding. He who would arrive at sound conclusions on this or any subject should dismiss prejudices and preconceived opinions and follow the truth, no matter to where it leads.

Perhaps the most direct declaration of the true principles of scientific breeding is to say that they are comprised wholly in the law of heredity, and that just so far as any theory agrees with this universal law it is right; but at the point where any theory conflicts with a known principle of heredity, there does it leave the realm of reason and truth and rest itself in error. Horses, as well as men, are what they inherit, or rather, I should say, the creatures of inherited characteristics and instincts. In the blood of every being is represented the distinctive qualities of both its parents, and through them his four grand parents, eight great-grand parents, and so on until, if we go back five generations, we find he has a line of inheritance to thirty-two distinct sources. In this being, the characteristics of one ancestor may dominate; in his full brother the peculiarities of another in the line of inheritance may rule. And so if we investigate we find that every peculiarity, every virtue, every vice, every talent, every weakness noticeable in the living subject of to-day had its counterpart in some degree, if not in the immediate parents, in some ancestor more or less remote. This truth we express in the oft-quoted maxim: Like produces like or the likeness of some ancestor.

It is, then, patent to the mind that the more diverse the inherited capacities of the parents are the less certainly can we foretell what special qualities will be most conspicuous in the offspring. If one special characteristic was noticeable in the parents, the grand parents, and the great-grand parents, the offspring is infinitely more certain to have that special characteristic in a highly developed form than if some of the ancestors were remarkable for an antagonistic characteristic. It is by the light of this law which gives uniform results in exact proportion to the strength and harmony of the inheritance that we must be guided in breeding, and if we are to succeed this truth must be the foundation on which we build.

Scientific breeding consists in throwing the strength of all the inherited tendencies into one channel, concentrating all the ruling forces on one objective point, and thus aiming at a certain result. If the purpose be to get a draft horse, it then behooves us to mate a sire and dam of draft blood that have themselves shown their capability at a draft horse's work. If we want a running horse, reason tells us to go to a running-bred stallion with a running-bred mare, and both the stallion and mare should be animals that have demonstrated their ability to run fast. If either had a trotting-bred sire or dam or a trotting-bred grandsire or grandam, our chances of getting a phenomenal runner are much diminished, for then the inheritance is not unbroken—it is divided. And the same reason that tells us to get a draft horse or a running horse does not desert us in breeding the trotter. We should couple a sire or dam of trotting inheritance and that are themselves trotters, and we must judge of the merits of the prospective colt according to the trotting

merits of the sire and dam, the grandsire and grandam, and so on backward, our chances being in proportion to the strength and unity of the inheritance. If we find trotting and trotting-bred ancestors for four or five generations backward, we can expect success in a measure corresponding to the trotting merits of these ancestors, and especially the immediate ones, and the nearer we find a blood line broken by the influx of a current calculated to neutralize the trotting instinct, the greater is the danger of our colt developing tendencies averse to the steady, fast trot.

All the varying types of animals of the same species are descendants of common ancestors. The clumsy, lumbering cart-horse and the fleet and beautiful racer have come to us from a common source. The difference from the original type, or rather the evolution of many types from one, are the result to effect which many and complex causes were contributive. The same variety of animals subjected to different environments, conditions, and uses will through time so change in characteristics that the unthinking would question that they sprang from a common parentage.

A radical divergence from an original type can be effected, and, indeed, a variety created, we might say, by developing a special acquired characteristic by exercise and use, and by breeding for the perpetuation and reproduction of that special characteristic. When racing began in England horses were trained and used for the race and then selected to breed for their racing capacity. Thus through a long series of generations the English evolved from the coarse native stock and the Arab a horse essentially different from either, and vastly superior to either in the special use for which the variety is bred—the capacity to race at the gallop. The evolution of the trotting breed, yet in its infancy, proceeds on the same principle.

The offspring of the first pair in which a special habit was developed would, as a rule, excel at that habit more readily than either of their parents. But as reversion to more or less remote ancestors is a principle in inheritance, the offspring of this pair might inherit strongly the characteristics of their grand parents, in which the special habit for which the breeder is striving has not been acquired. Hence, early after grafting a quality in the blood the transmission of that quality is very uncertain. The chances of reversion to grand parents are much less than to parents; to great-grand parents much less than to grand parents, and so on. The risk of reproducing an undesirable quality of an ancestor is lessened as we breed away from that ancestor. On the other hand, by developing an acquired habit in every generation and selecting and mating parents possessing that habit or qualification in the highest degree, we gradually fix it as a matter of inheritance and instinct, and in each generation, as we proceed, the certainty of success in reproducing the desired qualification becomes greater and the risk of failure less. If, then, every ancestor for all near (say five or six) generations were trotters our chances of producing a trotter are very great, but if some of the ancestors were not trotters or trotting bred a reversion to them is possible. The danger of failure to produce the quality we desire increases just in proportion to the number and contiguity of the ancestors not possessing that quality in the inheritance. "Heredity transmits with certainty only what becomes a fixed characteristic in the race."

The influence of selection in breeding can hardly be overrated, and the breeder who is wise will never forget that the dam is at

least as important as the sire. "Selection," says Youatt, "enables the agriculturist not only to modify the character of his stock but to change it altogether. It is the magician's wand by means of which he may summon into life whatever form and mold he pleases." Darwin, in his Origin of Species, says cogently: "We can not suppose that all the breeds were suddenly produced as perfect and as useful as we now see them; indeed, in many cases we know that this has not been their history. The key is man's power of accumulative selection; nature gives successive variations; man adds them up in certain directions useful to him. In this sense he may be said to have made himself useful breeds." How important, then, it is to make our selections accumulative; to at every cross accumulate an additional inheritance of the quality we seek to reproduce.

That acquired habits or capacities are strengthened by development and use is undeniable; and equally undeniable is it that by disuse acquired habits and capacities are lost. Darwin declares that "as modifications arise from and are increased by use or habit and are diminished or lost by disuse, so I do not doubt it has been the instincts." A very striking exemplification of the truth of this proposition is furnished in the history of American horse breeding. The case is so directly to the point, and so interesting, that I here transcribe the account as published years ago:

In Abbeville district, South Carolina, in the last century, Mr. Richard A. Rapley was a large breeder of thoroughbred horses. He was an Englishman, and brought over a number of the most fashionably bred stallions and mares that could be found in Great Britain. His taste and fancy led him to prefer the race-horse for all purposes of life on his estate, but he never trained or raced any of them. Believing in blood as he did, he was scrupulously careful in all the crosses he made; and thus he had a great herd of pure-bred animals that had never seen a race course. He kept up his fancy for many years and through several generations of horses. At last the attention of racing men was called to this elegant stud of pure-bred animals, and numbers of them were selected and tried; but with all their purity of lineage and superior elegance of form they were found not to be race-horses. The inheritance of speed had been neglected till it was lost for want of use of it.

To sum up, the following propositions may be accepted without qualification as principles that govern the transmission and reproduction of special qualities in all the animal world: (1) Acquired habits and instincts are transmissible and become hereditary. Therefore (2) habits of action may be created and established by training and use, and these habits become an hereditary instinct in the descendants of the animals in which they were established. (3) This hereditary instinct is increased, intensified, and strengthened by development, and is therefore transmitted by developed animals in an increased and intensified degree. (4) On the other hand, by non-development and disuse the instinct becomes weakened, and finally, in a series of generations, is lost.

I need not point the application of these principles in the business of breeding trotters. Their essence is, breed the trotter from parents that are trotters individually and trotters in inheritance.

Many superficial writers on the horse, trotter or runner, treat him simply as a machine, and forget that he has a mental organization. That the disposition to trot fast and the disposition to run fast are just as much hereditary instincts as is the disposition of the pointer dog to point no intelligent, thinking man will deny. I do not for a moment underrate the duty to be performed by the physical organization; but just as the muscles governing the fingers, the wrist, and the arm of the

writer obey his will in tracing the letters of a word, so do the muscles of a horse controlling the use of his limbs obey his will. Hence speed of any certain order is primarily a mental quality—an instinct. The physical structure is the machine, the will the motive power, and each is a mutual necessity. The trotting horse that can trot the fastest and the farthest is the one that has the strongest trotting instinct combined with the most perfect physical organization. While without the physical ability the instinct will not enable the horse to perform, neither will the most perfect form and structure make a trotter without the instinct to trot. The idea, then, that an animal of a certain form, with no trotting inheritance, is desirable to breed from for trotting speed is clearly fallacious, and he who advances it must forget the supremacy of the mental over the physical organization.

Notwithstanding this, it is no less the duty of the hour to breed for high form and form. I think in the constant striving after speed alone the essentials of form, size, and finish are being grievously overlooked. They may perhaps be overlooked without ruinous consequences to the breeder of turf horses, but he who would breed for the more solid purposes of every-day use and to meet an every-day market can not overlook them and succeed.

I have not set down these fundamental principles of breeding with the purpose of touching any but the great central truths with which no successful breeder can be unfamiliar. I have in this article merely sought to mark, by tracing his history and pointing his fitness for the every-day uses of the American people, the place the trotting-bred horse holds in the equine world, and the claims he has on the regard of the people of the nation. I am convinced that the American horse is the best type of the equine race, the most practical and the most valued. His importance to our commerce, the wide range of uses he serves so well, and his peculiar excellence and beauty in the places which no other type can fill are reasons sufficient that the American light-harness horse and the intelligent methods of his production should hold a foremost place in the business of the agricultural classes of the nation.

INDEX.

A.

F.

G.

L.

M.

N.

O.

Q.

R.

S.

T.

U.

V.

W.

Z.

O